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SOME METEOROLOGICAL ASPECTS OF NEBRASKA TORNADOES

By Hoyt Lemons

[Department of Geography, University of Nebraska, February 1938]

INTRODUCTION

The tornado, as is well known, has its genesis at the lower cloud level. At a propitious moment the whirling funnel-cloud descends to the ground, raising a mighty cloud of dust and debris. Having run its course on the ground, the lower section of the funnel-cloud may dissolve, while the upper portion continues its travel in mid-air or dies out at the cloud level. Exemplary and illustrative of these phases of a tornado's existence are the accompanying photographs taken at York, Nebr. The funnel-cloud, as shown in figure 1, is descending earthward. In figure 2 it has reached the ground and is attended by a swirling cloud of dust and debris. As shown in figure 3 the funnel-cloud has assumed the appearance of a rising phenomenon due to the dissolution of its lower section; the dust whirl is still existent.

TIME-AREAL DISTRIBUTION

From a study of Nebraska tornadoes as observed and recorded by the United States Weather Bureau and their cooperative observers in Nebraska from 1916–37, it was found that the State experienced 121 tornadoes during the 22-year period.[1] Most of these storms originated within the State. Less than 20 entered from adjoining States, most of them coming from Kansas. These 121 tornadoes were concentrated in the general eastern and southern sections with detailed concentrations in northeastern, southeastern, and south-central Nebraska (fig. 4). The northwestern section of the State experienced the fewest tornadoes, only eight being recorded for the entire Panhandle area. In proportion to size Madison County in the northeast ranked first among the counties of the State in total number of tornadoes experienced.

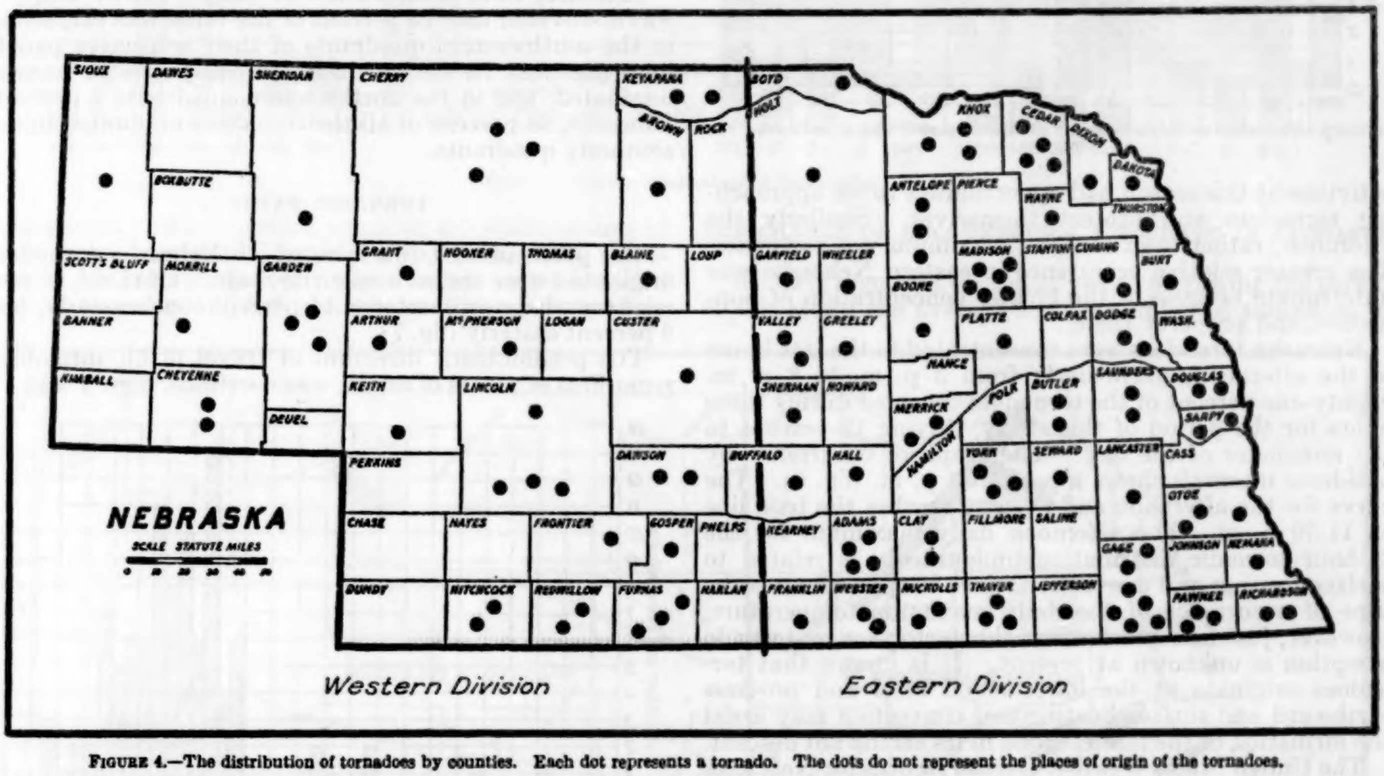


Figure 4.—The distribution of tornadoes by counties. Each dot represents a tornado. The dots do not represent the places of origin of the tornadoes.

The average yearly occurrence for the State was 5.5 tornadoes. Imagining a uniform distribution of these over the State, only one tornado would have visited each 14,000 square miles. The actual number of tornadoes per year varied from 1 to 14 (fig. 5). Moreover, the numbers varied widely with consecutive years. In 1930 there were 13 tornadoes; in 1931 the minimum, 1, was recorded.

The tornado "season" consists of spring, summer, and early autumn, lasting through the 7-month period, March

[1] This discussion and the accompanying illustrative graphs and map are based on data secured from the U. S. Weather Bureau Office, Lincoln, Nebr.

to September (fig. 7). March 14, 1919, was the earliest day of spring having a recorded tornado; while September 28, 1923, was the latest day of autumn with one recorded. No tornadoes occurred in the late autumn and winter months, October to February, inclusive. The curve of monthly tornadic occurrence for the "tornado season" reveals a minimum in March and a maximum in May, followed by a secondary maximum in September (fig. 7). The occurrence of the maximum number in spring rather than in late autumn or winter was fortunate for human life, since many people engaged in out-door

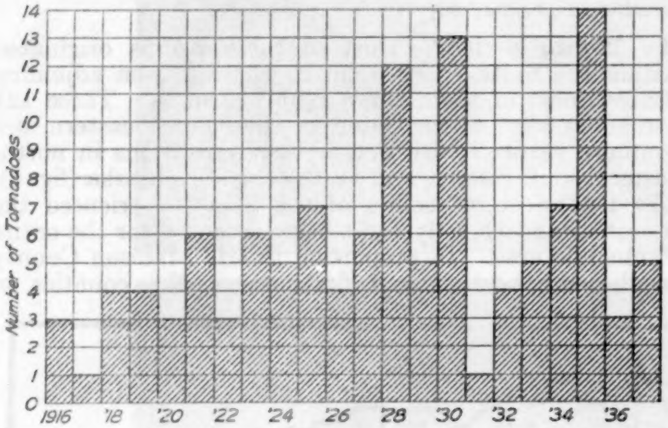


FIGURE 5.—Tornadoes in Nebraska during the 22-year period, 1916-37, inclusive. (121 tornadoes.)

activities at this season had opportunities to see approaching tornadoes and protect themselves. Similarly the afternoon, rather than a night, maximum was fortunate. The greater relative occurrence in eastern Nebraska was unfortunate because of the greater concentration of population and property there.

Nebraska tornadoes were concentrated in the late hours of the afternoon, particularly from 3 p. m. to 8 p. m. Eighty-one percent of the tornadoes occurred during these hours for the period of this study, leaving 19 percent to the remainder of the day. The graph of occurrence by half-hour intervals shows a peak at 4 p. m. (fig. 6). The curve for the afternoon and evening reaches the base line at 11:30 p. m. The afternoon daily maximum for the 24-hour tornadic distribution undoubtedly is related to surface heating and convection, since it approximates the time of occurrence of the daily maximum temperature. However, just how much effect this factor has on tornado inception is unknown at present. It is known that tornadoes originate at the lower cloud level and progress earthward and surface heating and convection may assist the formation of the funnel-cloud in its earthward descent.

The United States Weather Bureau records for Nebraska show that a majority of the storms, 71 percent of those recorded, occurred in the eastern section while only 29 percent occurred in the western (fig. 4). However, as Weather Bureau stations and towns are more numerous, and population is more dense in eastern than in western Nebraska, the chances are that a greater percentage of the tornadoes occurring were seen and reported in the former than in the latter area. Weather Bureau officials rely for much of their tornado information on eyewitnesses and on small-town newspaper reports. Nevertheless, the more logical and generally accepted reason is the location of eastern Nebraska. This section, more so than the western, lies in the paths and meeting places of two types of air masses—the southward-flowing, cold, dense masses from the north, and the northward-moving, warm, moist masses from the Gulf region. The meeting of these air masses provides the necessary meteorological conditions for tornadic inception.

TORNADIC INCEPTION

Daily weather maps for all days on which tornadoes occurred in the 22-year period were examined with the view of determining, if possible, the number of storms which originated at or near surface fronts. Only the tornadoes originating along surface fronts could be ascertained as the daily weather maps are based primarily on surface data. Sixty-eight percent of the storms positively were of the surface cold-front variety, and 27 percent gave strong indications of surface cold-front origin (fig. 7). One percent originated at surface warm-fronts, 3 percent indicated similar places of inception, and for 1 percent no clues existed on the maps as to their places of origin. It is possible that the latter were of the upper cold-front variety. The majority, 95 percent, of Nebraska tornadoes issued from surface cold fronts or inception was indicated there.

Likewise, from examination of daily weather maps it was discovered that 65 percent of the tornadoes originated in the southwestern quadrants of their respective parent lows (fig. 7). In the northeastern quadrants 11 percent originated, and in the northwestern quadrants 3 percent. However, 86 percent of all the tornadoes originated in the southerly quadrants.

TORNADIC PATHS

The paths of all LOWS from which Nebraska tornadoes originated were traced across the State. Of these, 80 percent traveled northeasterly, 11 percent southeasterly, and 9 percent easterly (fig. 7).

The predominant direction of travel of all tornadoes, regardless of places of origin, was northeast (figs. 7 and 8).

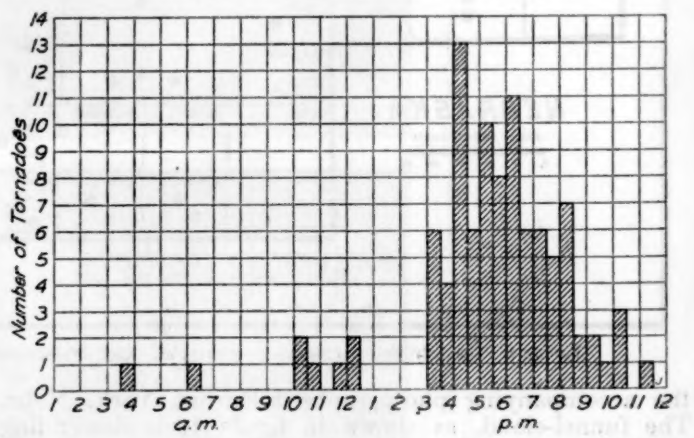


FIGURE 6.—Occurrence of tornadoes by half-hour intervals for the 22-year period, 1916-37, inclusive. (99 tornadoes.)

This accounted for 63 percent. The other 37 percent were divided between northwesterly, northerly, easterly, southeasterly, and southwesterly directions with 16 percent taking the southeasterly course. That tornadoes may follow directions other than general easterly ones is evidenced by those in the present instance which moved north, northwest, or southwest. Tornadic paths in Nebraska for the period studied varied in length from a few yards to 95 miles with a median length of 7.5 miles.

In width they ranged from 16 yards to 1,760 yards with a median width of 288 yards (fig. 8).

RELATIONSHIPS

Certain characteristics of the tornadic origins and travels seemed definitely related to certain features of

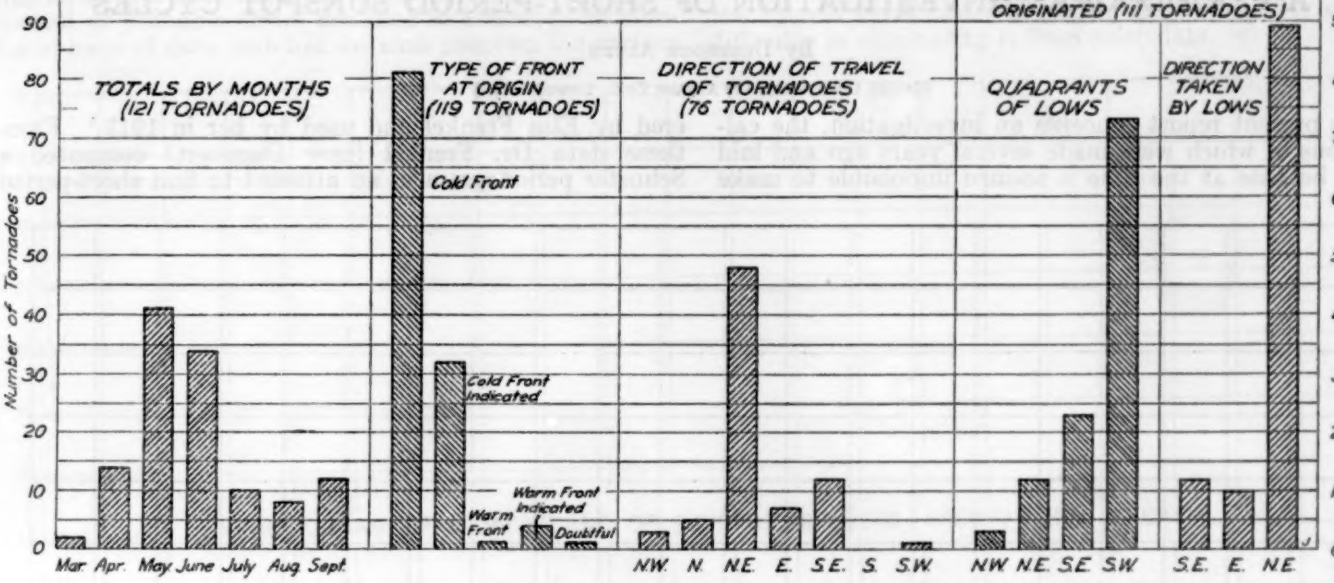


FIGURE 7.—Various classifications of the tornadoes.

their parent LOWS. Surface winds of the warm sectors of LOWS move in general easterly and northeasterly directions. An examination of daily weather maps revealed that a majority of Nebraska tornadoes originated in southern quadrants and subsequently traveled northeastward, indicating a relation between the direction of tornadic travel and the direction of the lower winds in the quadrant of origin (fig. 7). Moreover, a relation appeared to exist between the direction of travel of the parent LOW and the direction of travel of the offspring tornado. The examination showed that 63 percent of the tornadoes traveled in northeasterly directions across Nebraska, and that 11 percent of the lows and 16 percent of the tornadoes traveled in southeasterly directions.

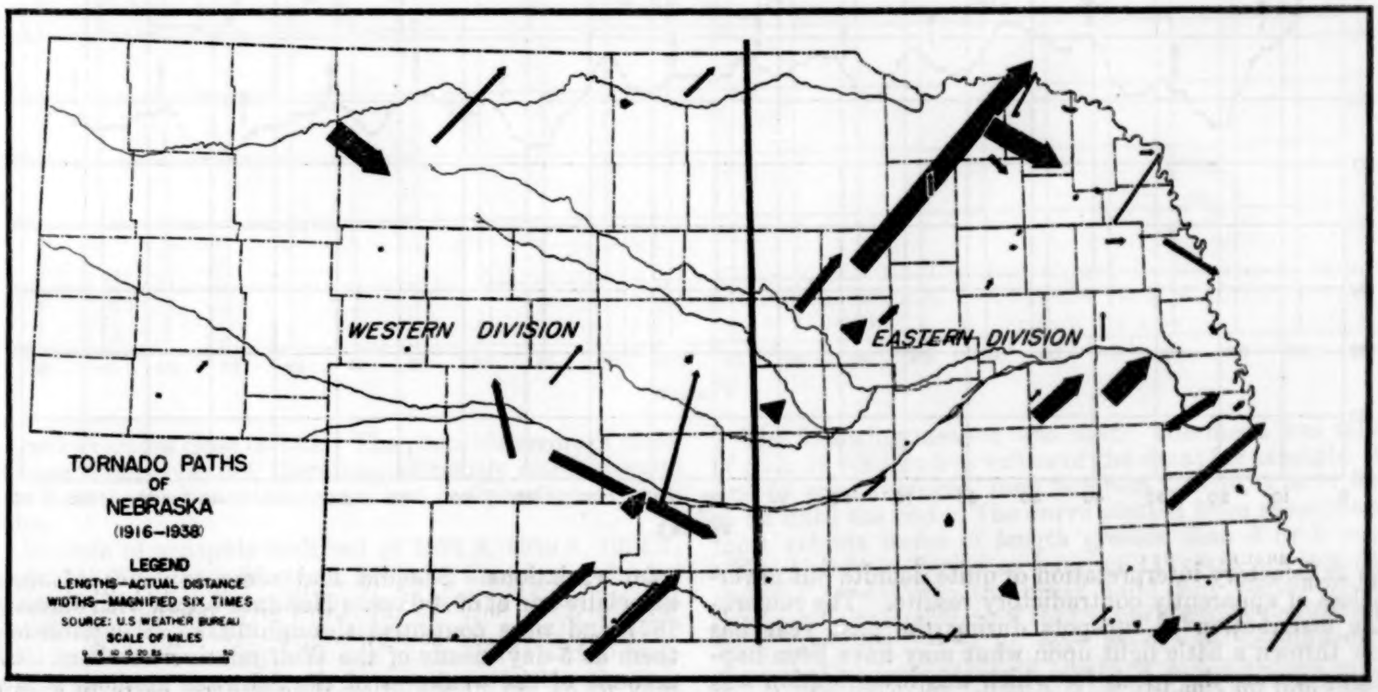


FIGURE 8.

THE CHANCE OF ENCOUNTERING A TORNADO IN NEBRASKA

We have seen that for the 22 years comprising the period of this study the average annual number of tornadoes in Nebraska was 5.5, with an average path 7.5 miles in length and 288 yards in width, or an average land coverage of 1.2 square miles each. This makes an average annual land coverage of approximately 7 square miles. There are

76,808 square miles of land in Nebraska, so that, assuming a uniform areal distribution and that no place would be visited a second time, more than 10,000 years would be required before all localities in the State would experience a tornado. Therefore, the chance of one encountering such a storm in the State, once in more than 10,000 years, is remote indeed. Furthermore, the average annual number of deaths from tornadoes in Nebraska during this period was approximately 1.5. Therefore, as the population of the State is around one and a half million the chance that an individual will lose his life in a tornado is only about one in a million.

A PERIODOGRAM INVESTIGATION OF SHORT-PERIOD SUNSPOT CYCLES

By DINSMORE ALTER

[Griffith Observatory, Los Angeles, Calif., December 1937]

The present report concerns an investigation, the calculations of which were made several years ago and laid aside, because at the time it seemed impossible to make any satisfactory interpretation of quite definite but nevertheless of apparently contradictory results. The remarkable distribution of sunspots during the past year has now thrown a little light upon what may have been happening during the epoch for which this investigation was made, and makes it appear best to publish the results of an extremely long calculation. The data are those gathered by Elsa Frenkel and used by her in 1913.[1] From these data Dr. Frenkel (now Dagobert) computed a Schuster periodogram in an attempt to find short-period solar variations. She did find some evidence of such, especially one of 69.4 days. Her data began with January 1877 and were continued through 1911. She published them as 5-day means of the Wolf relative numbers. On account of the weakness of the Schuster method, it was very difficult to find any definite results.

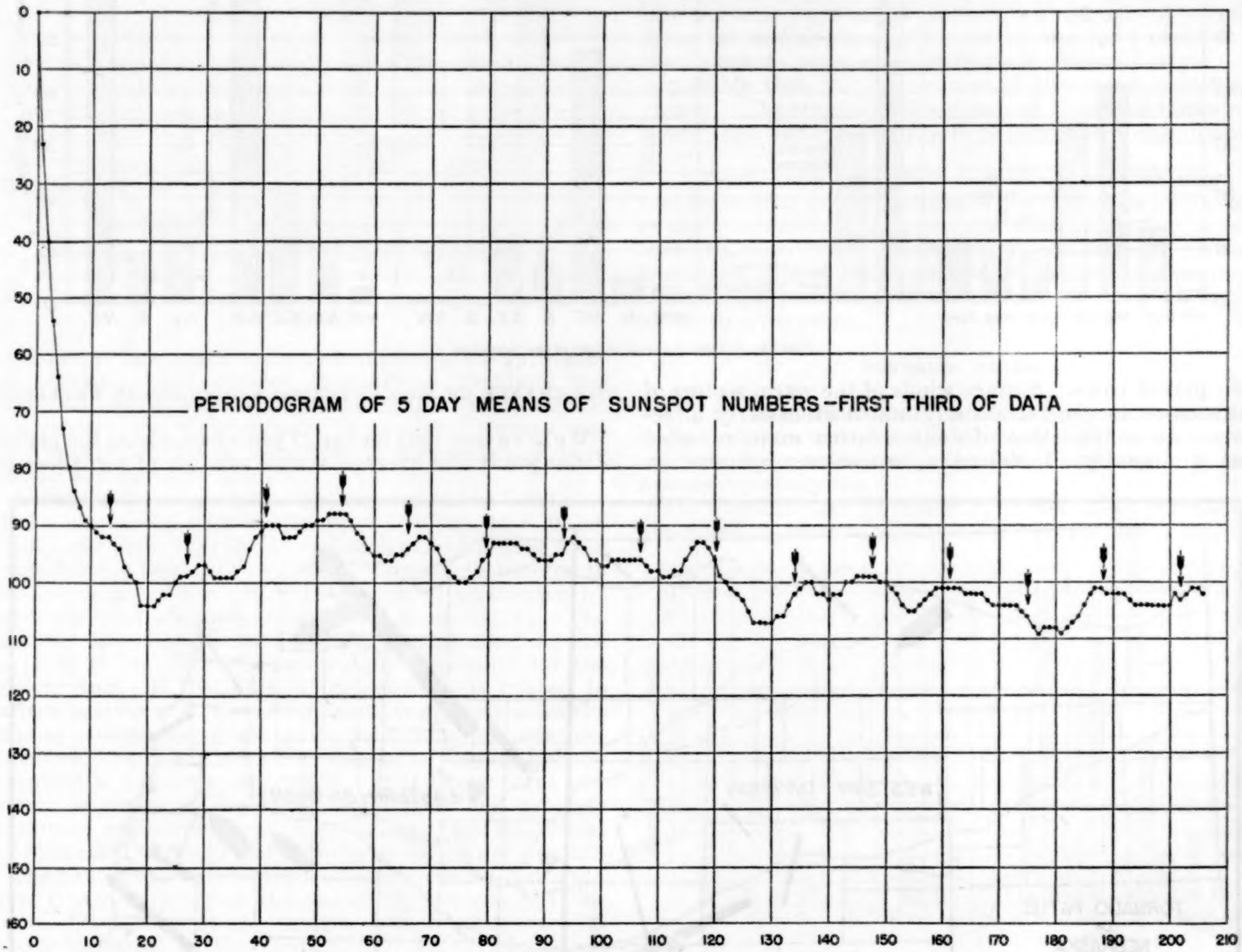


FIGURE 1.

In the present investigation a new form of periodogram of linear type was used.[2] This periodogram uses as an

[1] Frenkel, Elsa. 1913. Untersuchungen über kurzperiodische Schwankungen der Häufigkeit der sonnenflecken. Publikationen der Sternwarte des eidgenössischen Polytechnikums. Band V.

[2] Alter, Dinsmore. 1937. A Simple Form of Periodogram. The Annals of Mathematical Statistics. Vol. 7, No. 2, p. 121.

index the standard deviation of the errors of predictions by the hypothesis that data will be repeated after a given lag or cycle. As in the case of all other periodograms, these lags are tried for all integral values. The factor 0.85 has been included in the indices in the accompanying diagrams to give the probable errors of predictions by the various trial hypotheses. In all more recent calculations this factor has been changed, so that standard deviations instead of probable errors are used in them. The number of pairs of data matched for each point on the various

In any form of periodogram calculation a difficulty is always encountered when there exists in the data some long cycle or period which is not under investigation. As an example, in meteorological data, we usually eliminate the annual term. In the case of these sunspot data the troublesome term has a length of a little more than 11 years. The range of periodicities investigated here has a maximum length of not more than 2 years. The fact that the 11-year cycle varies in length and in intensity causes difficulty in eliminating it from solar data.

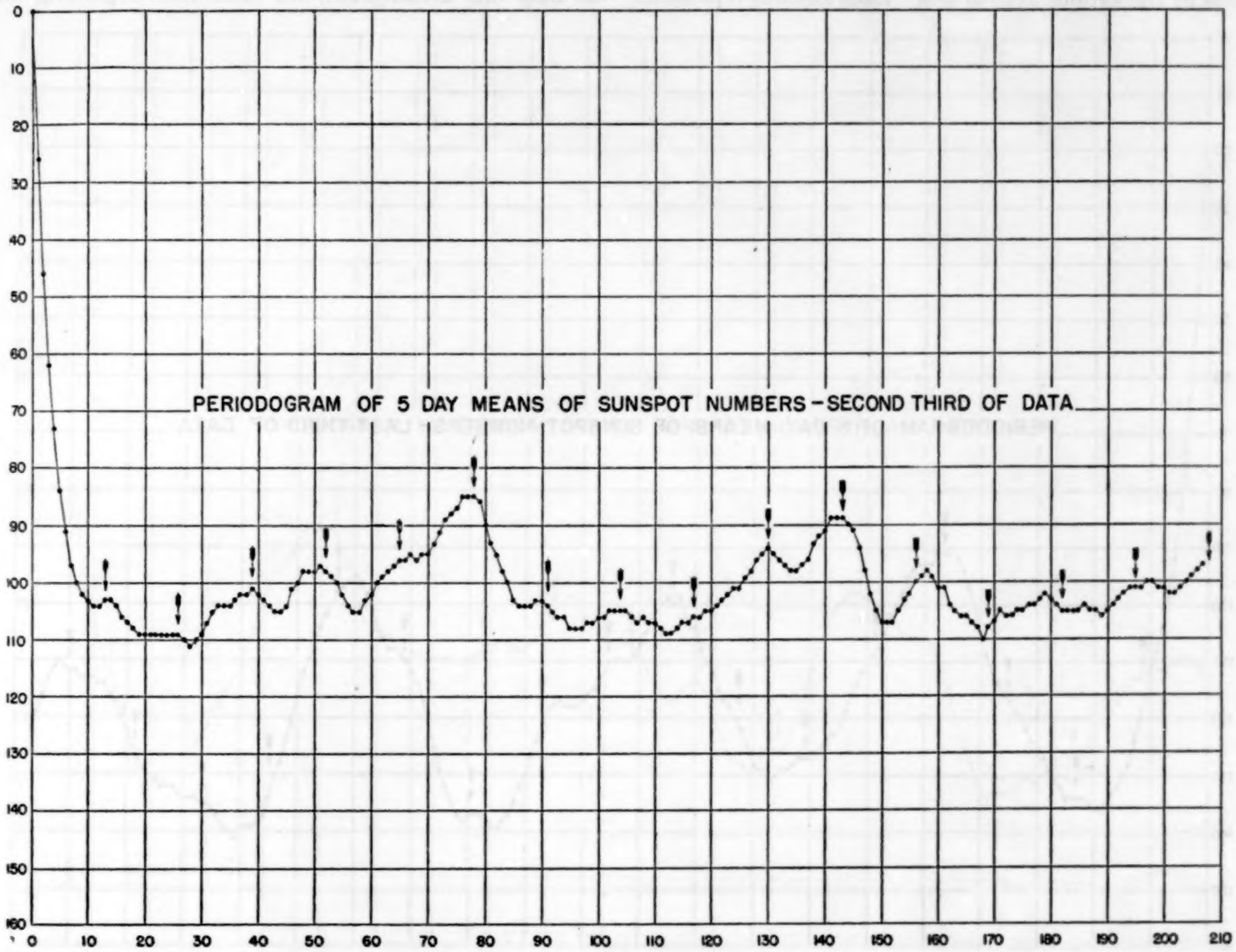


FIGURE 2

curves averages close to 750. The probable errors of these indices themselves are, therefore, extremely small, despite the fact that adjacent data are not independent of each other.

Minima of sunspots occurred at 1878.9, 1889.6, 1901.7, and 1913.7. These 35 years of data, therefore, without serious error may be considered as covering three sunspot cycles from minimum to minimum. It appeared practical to divide them approximately into thirds and to compute periodograms separately, to learn whether there is significant resemblance of short-period terms from one sunspot cycle to the next. Finally all the data were combined into one periodogram in an attempt to find out whether any cycles of solar variation had persisted through perhaps several hundred repetitions.

The following method was used: The mean was taken of each 59 consecutive values of the data; for example, the first 59 were averaged, then numbers 2 to 60, 3 to 61, and so on until the end. The curve plotted from these means must exhibit terms of length greater than 4 or 5 years quite plainly. Terms as long as 11 years are scarcely damped at all. On the other hand, any period of 295 days or of a submultiple of that value is entirely eliminated from the data. It is an easy matter of calculation to show that no term of length less than, say, 400 days would remain in these means with any appreciable amplitude. Next, each mean was subtracted from the middle datum of the 59 data used in securing it. These differences are almost entirely free from long-period terms. However, they do contain the short-period terms nearly unchanged,

although with a very slight bias toward the submultiples of 295 days.

These differences were used in computing the periodogram. The numbers were in general quite small, which shortened the work. The resulting periodograms for each third of the data are exhibited as figures 1, 2, and 3. The abscissae are expressed in terms of Dr. Dagobert's pentads. For a lag of 0, the periodogram factor is, of course, zero. It has been stated earlier that the ordinates used for the periodograms are the probable errors of predictions by the various hypotheses. Each abscissa represents one hypothesis concerning the existence of a cycle. Chance or, in other words, zero correlation, gives an ordinate of 8.95 for the first third of the data. The second third of the data has 9.37 for the random expectancy of this probable error. The last third has 10.94. For the first half dozen pentads the curve drops rapidly, because the dependence of one pentad on the preceding ones extends over little more than a month. After a few pentads, independence is reached and from there on the pattern is determined by cycles which exist in the data, such cycles being due either to accidental variations or to more or less permanent physical causes.

The first third of the data shows very little amplitude to the swings. Arrows have been drawn at intervals where the best repetition of periodogram peaks is found. These hold quite nicely for a cycle of length 68.0 days until after it has b en repeated seven times. From then on the agreement seems perhaps a little better than accidental although there is little that can be claimed for it. Such a pattern is that which would be due to a cycle of unconstant length averaging at the value stated. When such cycles exist in data, the first peaks must show up most strongly, but as repetition is continued, they must become, in general, less clear. If this 11-year sunspot cycle had been the only one investigated, the conclusion regarding the existence of short cycles certainly would have been negative. These data do not by themselves give a periodogram pattern strong enough to carry conviction. However, if in other stretches of data amplitudes are found which cannot be accidental, any *a priori* argument against the 68.0-day cycle must fail, and it must be considered as quite probably having a real existence during the years studied.

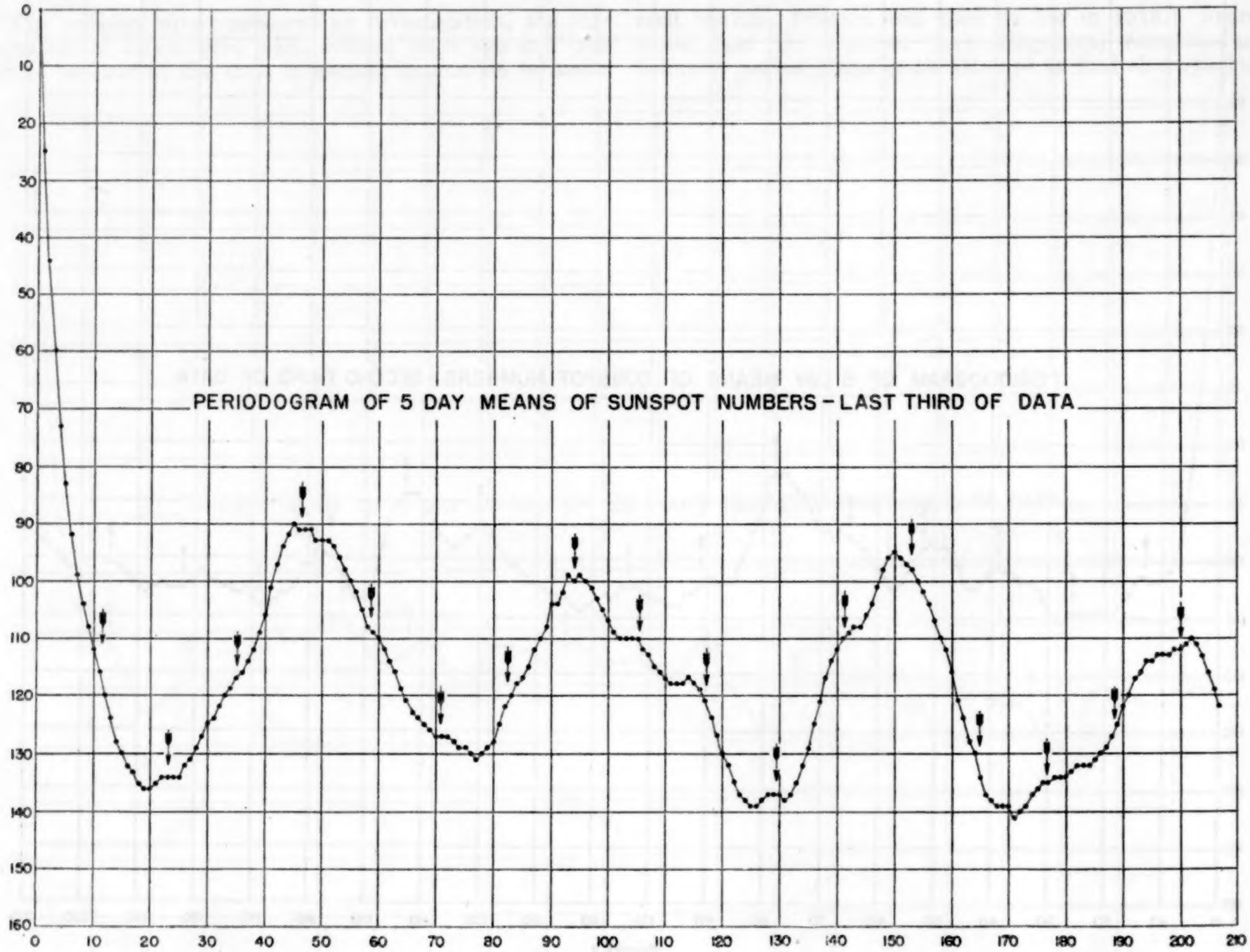


FIGURE 3.

With the second third of the data, a very different type of pattern begins to appear. Two peaks stand out high above all others. One of these is spread over the lags from 75 to 79 pentads; the other from 140 to 145. The latter is, within accidental range, double the former. Counting the small peaks between, it is found that they are spaced

at quite regular intervals with the sixth one occurring at the first of these high peaks and the eleventh occurring at the second The twelfth one follows almost perfectly at a sharp peak at pentad 158. The variations are too large to be accidental, when one considers that there are 800 pairs of data used in the calculation of each point. Examination of the peak between 70 and 80 shows that its left side is much less steep than the right. The same thing occurs at the second peak. The pattern is almost perfectly that which would be secured from a long cycle of length about 360 days with one of 65.0 days superposed case—65.0 against 68.0 days. Such a peculiarity of distribution of sunspots as has occurred during 1936–37, when one-half of the sun has been far more spotted than the other, could easily account for a far greater discrepancy than is found here, even if one were investigating an hypothesis of a periodicity of unchanging length.

With the last third of the data, the periodogram becomes much more striking than it was before. There has now appeared a very definite cycle of length a little less than 250 days that far outshadows everything else. Its amplitude is so large, and the regularity of the peaks obtained

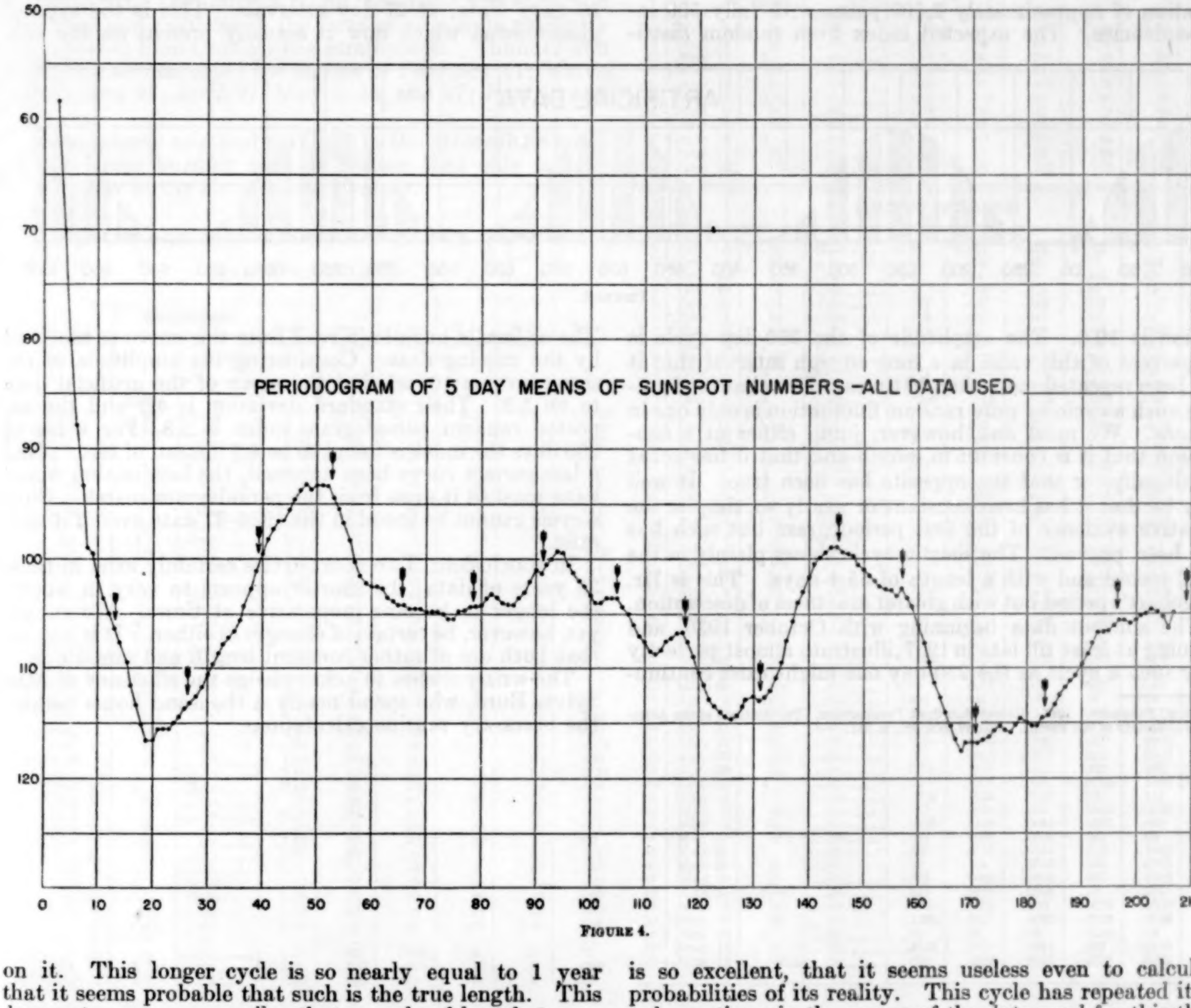


Figure 4.

on it. This longer cycle is so nearly equal to 1 year that it seems probable that such is the true length. This does not mean, necessarily, that a cycle of length 1 year existed on the sun (although that is possible), for the result is most probably explained by the annual variation of altitude of the sun in the sky, which would tend to reveal less of the small spots during the winter than during the summer. An objection to this conclusion lies in the fact that this annual term is not found in the other parts of the data.

The short period found is much more regular in its appearance and is of decidedly greater amplitude than that which was indicated for the first 11 years. However, the length of the period is nearly the same as in the former is so excellent, that it seems useless even to calculate probabilities of its reality. This cycle has repeated itself a dozen times in the course of the data used for this third periodogram. Its length is one-eighteenth of the interval between the sunspot minima which limit these data. This is half the length of the only rainfall cycle that has been found very widely on the earth, namely one whose length equals the ninth harmonic of the sunspot cycle. This periodogram shows also the superposition of a short-period term of length 58.8 days.

It should be noted that beginning with 1867.2 four consecutive intervals between sunspot minima are as follows: 11.7, 10.7, 12.1, 12.0 years. The intervals covered by this investigation are the last three of these. The first

periodogram covered a cycle which was a year shorter than the preceding one and 1.4 years shorter than the following one. The variation of the cycle indicated an unusual disturbance of the sun. The last third, for which a very regular periodogram pattern has been found, occurs at a time when there has been little change in the length of the cycle and when, apparently, solar conditions have become better stabilized. It would appear reasonable that such conditions would better exhibit such short cycles as exist.

The fourth periodogram is that from the whole 35 years of data. The individual points each represent the combination of approximately 2,500 pairs, with fully 500 independencies. The expected index from random distribution is 10.0. The amplitude of the 250-day cycle is 62 percent of this value in a long enough interval that it has been repeated more than 50 times. The chance of getting such a cycle by pure random fluctuation is only one in billions. We must not, however, jump either at a conclusion that it is constant in length and that it has acted continually, or that the opposite has been true. It well may be that it has been constant or nearly so, despite the negative evidence of the first periodogram but such has not been proved. The shorter cycle shows plainly in the total record and with a length of 65.4 days. This is Dr. Dagobert's period but with greater exactness of description.

The sunspot data beginning with October 1936, and running at least till late in 1937, illustrate almost perfectly why such a cycle as the 250-day one might exist continuously but fail to show in certain epochs.[3] They also can explain an apparent variation in the length of the shorter cycle. During these months the very great majority of the sunspots have occurred on one-half of the sun, so that even with no actual variation there would appear to be a very strong and regular periodicity of length equal to the synodic rotation period of the sunspot belt, i. e., 27.0 days. Such predominance of a hemisphere has been noticed as continuing through many years for northern and southern hemispheres but apparently little search has been made for a longitudinal localization. Figure 5 shows a sine curve of period 250 days, with omission of 10 days' data, at 27-day intervals. This is the type of phenomenon which now is actually present on the sun.

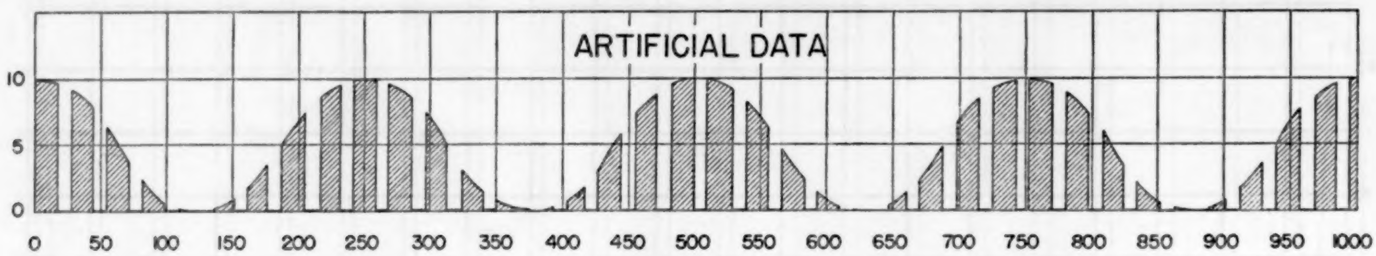


FIGURE 5.

The ordinates have been read from this curve as modified by the missing data. Considering the amplitude of the sine curve as 10, we find the mean of the artificial data to be 3.3. Their standard deviation is 4.1 and the expected random periodogram index is 5.8 For a lag of 250 days the index is found to be 4.5 instead of zero. Had a less perfect curve been assumed, the localization would have masked it even from the periodogram search. Such a cycle cannot be found in the 1936–37 data even if it does exist.

In conclusion: Two short cycles certainly exist in these 35 years of data; the shorter appears to vary in length, the longer to become inoperative at times. We cannot yet, however, be certain of changes in either. It is *possible* that both are of rather constant length and amplitude.

The writer wishes to acknowledge the efficiency of Miss Sylvia Burd, who spend nearly a thousand hours making the necessary routine calculations.

[3] Alter, Dinsmore. 1937. Recent Sun-Spot Peculiarities. Publications of the Astronomical Society of the Pacific. Vol. 49, No. 291, p. 242.

ANALYSES OF RAINS AND SNOWS AT MOUNT VERNON, IOWA, 1937–38

By NICHOLAS KNIGHT

[Cornell College, Mount Vernon, Iowa, June 1938]

During the school year 1937–38, the analysis of the rains and snows at Mount Vernon was continued; these analyses have been made for about 30 years. The present group consists of the analyses of 55 specimens.

The rainfall of November 1, 1937, was accompanied by thunder and lightning. The small shower of November 8 was accompanied by lightning.

During the December 8 storm, the wind was strong in the west and particles in the form of dust were evidently transported here through the atmosphere. Thunder and lightning accompanied the storms of February 11; March 16, 22, and 25; April 27; May 4, 18, and 27; June 10 and 15.

As sulphuric acid and sulphate in the atmosphere come mainly from burning coal, it follows that only a little sulphate is in the air in warm weather.

The rains and snows of Mount Vernon, Iowa, 1937–38

PARTS PER MILLION

No.	Date	Precipitation		Chlorine	Free NH_3	Alb. NH_3	N in nitrate	N in nitrite	Sulphate
		Amount	Kind						
		Inches							
1	Oct. 5	3/5	Rain	3.75	0.40	0.14	0.5	0.8	0.0007
2	Oct. 9	3/10	do	2.13	.30	.136	.8	.12	.0007
3	Oct. 10	1/3	do	3.55	.45	.44	.2	.14	.007
4	Oct. 18	3/4	do	3.60	.40	.20	.6	.7	.00
5	Oct. 19	1 1/4	do	2.10	.20	.16	.8	.45	.014
6	Nov. 1	1/2	do	3.00	.28	.40	.95	.62	.007
7	Nov. 8	1/10	do	3.75	.42	.38	.66	.9	.01
8	Nov. 19	3	Snow	3.00	.30	.36	.45	.54	.014
9	Nov. 27	1/3	Rain	4.00	.30	.50	.90	1.2	.014
10	Nov. 27	4	Snow	1.5	.20	.18	.15	.00	.00
11	Dec. 7	1 1/2	do	3.55	.30	.22	.5	.8	.0009
12	Dec. 8	1	do	3.60	.42	.40	.8	1.00	.011
13	Dec. 13	4	do	3.00	.28	.25	.65	.75	.012
14	Dec. 15	1/2	Rain	2.40	.36	.32	.40	.42	.010
15	Dec. 19	4	Snow	3.60	.04	.40	.70	.70	.012
16	Jan. 9	4	do	7.10	.38	.24	.75	.85	.009
17	Jan. 19	1	do	4.00	.16	.40	.80	.80	.005
18	Jan. 24	1	Rain	2.00	.04	.32	.45	.49	.003
19	Jan. 26	1	Snow	1.25	.40	.30	.35	.20	.006
20	Jan. 30	3	do	1.50	.02	.40	.50	.30	.011
21	Feb. 3	1/4	Rain	4.00	.04	.45	.50	.60	.014
22	Feb. 5	1/3	do	2.50	.32	.36	.65	.85	.01
23	Feb. 6	7/10	do	3.00	.08	.36	.70	.75	.009
24	Feb. 11	1/10	do	3.25	.136	.50	.9	.85	.018
25	Feb. 17	3/5	do	1.00	.15	.40	.75	.90	.0076
26	Mar. 4	1/2	do	1.50	.020	.38	.70	.80	.009
27	Mar. 9	4	Snow	1.00	.030	.40	.75	.65	.0024
28	Mar. 15	1	Rain	2.00	.05	.45	.77	.70	.006
29	Mar. 16	9/10	do	.50	.24	.40	.85	.75	.005
30	Mar. 22	2/3	do	2.50	.30	.40	.90	.65	.004
31	Mar. 25	1/4	do	1.50	.30	.38	.65	.80	.011
32	Mar. 29	1 1/2	do	1.00	.05	.40	.50	.70	.00
33	Mar. 30	1/3	do	2.00	.20	.40	.75	.65	.001
34	Apr. 6	1 3/5	do	1.00	.112	.42	.5	.50	.004
35	Apr. 7	3	Snow	3.55	.20	.28	.3	.75	.008
36	Apr. 15	3/5	Rain	1.50	.35	.40	.60	.65	.006
37	Apr. 16	1/3	do	1.00	.35	.24	.75	.50	.005
38	Apr. 23	1/10	do	3.55	.30	.40	.50	1.00	.007
39	Apr. 25	1/3	do	------	------	------	------	------	------
40	Apr. 26	1/3	do	1.5	.02	.056	.6	.8	.01
41	Apr. 27	1	do	1.6	.015	.025	.35	.6	.002
42	May 4	1	do	.75	.010	.04	.7	.5	.00
43	May 7	1/4	Rain	1.00	0.025	0.035	0.6	0.8	0.0015
44	May 8	3/8	do	.50	.05	.045	.75	1.00	.004
45	May 14	3/5	do	1.25	.04	.05	1.00	.55	.009
46	May 17	1	do	1.50	.05	.045	.50	.65	.005
47	May 18	3/8	do	2.00	.045	.05	.40	.85	.0000
48	May 20	1/3	do	1.00	.06	.045	.75	.70	.0000
49	May 27	1 1/10	do	1.25	.045	.04	.50	.90	.0000
50	June 3	1/5	do	1.50	.05	.45	.70	.50	.005
51	June 6	1/3	do	3.55	.26	.14	.50	.35	.006
52	June 10	2	do	1.00	.02	.035	.40	.25	.00
53	June 14	1/5	do	4.30	.03	.03	.60	.30	.00
54	June 15	15/100	do	1.50	.04	.035	.70	.40	.00

POUNDS PER ACRE

No.	Date	Amount	Kind	Chlorine	Free NH_3	Alb. NH_3	N in nitrate	N in nitrite	Sulphate
1	Oct. 5	3/5	Rain	0.85	0.001	0.032	0.113	0.18	0.0002
2	Oct. 9	3/10	do	.49	.092	.03	.17	.027	.0001
3	Oct. 10	1/3	do	.81	.10	.10	.046	.03	.0016
4	Oct. 18	3/4	do	.61	.068	.024	.10	.12	.00
5	Oct. 19	1 1/4	do	.622	.057	.045	.023	.127	.004
6	Nov. 1	1/2	do	.339	.032	.045	.107	.07	.0005
7	Nov. 8	1/10	do	.066	.01	.009	.016	.0022	.00024
8	Nov. 19	3	Snow	.171	.017	.021	.021	.031	.0008
9	Nov. 27	1/3	Rain	.18	.0136	.0226	.041	.054	.0006
10	Nov. 27	4	Snow	.114	.0152	.0137	.0114	.00	.00
11	Dec. 7	1 1/2	do	.090	.0084	.0062	.014	.0224	.000
12	Dec. 8	1	do	.1008	.0118	.0112	.0224	.028	.00021
13	Dec. 13	4	do	.225	.0215	.0188	.0488	.563	.0009
14	Dec. 15	1/2	Rain	.27	.041	.0365	.0456	.0479	.0011
15	Dec. 19	4	Snow	.27	.003	.03	.053	.053	.0009
16	Jan. 9	4	do	.54	.029	.018	.057	.065	.0007
17	Jan. 19	1	do	.076	.003	.0076	.0152	.0152	.0001
18	Jan. 24	1	Rain	.454	.0091	.0726	.1022	.1114	.0007
19	Jan. 26	1	Snow	.0237	.0076	.0057	.0066	.0038	.0001
20	Jan. 30	3	do	.0655	.0011	.0228	.0285	.0171	.0006
21	Feb. 3	1/4	Rain	.228	.0023	.0256	.0285	.0342	.0008
22	Feb. 5	1/3	do	.1125	.0144	.0162	.0293	.0383	.00045
23	Feb. 6	7/10	do	.204	.0054	.0245	.0476	.051	.0006
24	Feb. 11	1/10	do	.0738	.0031	.0113	.0204	.0193	.0004
25	Feb. 17	3/5	do	.132	.0198	.0528	.0999	.1188	.0010
26	Mar. 4	1/2	do	.1695	.0023	.0429	.791	.0904	.001
27	Mar. 9	4	do	.076	.0023	.0304	.057	.0494	.0002
28	Mar. 15	1	do	.454	.0113	.1021	.1748	.1589	.0014
29	Mar. 16	9/10	do	.10	.048	.08	.175	.15	.0010
30	Mar. 22	7/10	do	.225	.027	.036	.081	.0585	.0004
31	Mar. 25	1/4	do	.0855	.0171	.0217	.0371	.0456	.0006
32	Mar. 28	1 1/2	do	.4	.02	.16	.20	.28	.00
33	Mar. 30	3/10	do	.15	.0015	.003	.057	.049	.00007
34	Apr. 6	1 9/10	do	.363	.041	.15	.18	.18	.0015
35	Apr. 7	3	Snow	.20	.0114	.0116	.017	.017	.0005
36	Apr. 15	2/3	Rain	.228	.0532	.0364	.114	.0456	.0009
37	Apr. 16	1/3	do	.076	.0266	.0182	.057	.0228	.0002
38	Apr. 23	1/10	do	.081	.0069	.0092	.011	.0023	.0001
39	Apr. 26	1/3	do	.0675	.0009	.0025	.027	.036	.0005
40	Apr. 27	1	do	.75	.0034	.0057	.0795	.1365	.0004
41	May 4	1	do	.1725	.0023	.0092	.161	.115	.0
42	May 7	1/4	do	.057	.0014	.002	.0342	.0466	.0005
43	May 8	2/3	do	.0455	.0046	.0041	.0683	.091	.0004
44	May 14	3/5	do	.011	.0036	.0046	.091	.05	.0008
45	May 17	1	do	.345	.0115	.0104	.115	.1495	.0012
46	May 18	3/8	do	.18	.004	.0045	.036	.0765	.00
47	May 20	1/3	do	.076	.0045	.0034	.057	.0532	.00
48	May 27	1 1/10	do	.325	.0117	.0104	.13	.234	.00
49	June 3	1/5	do	.0675	.0023	.002	.0315	.0222	.0002
50	June 6	1/3	do	.1598	.0117	.0063	.0225	.0158	.0003
51	June 10	2	do	.45	.02	.09	.0158	.18	.00
52	June 14	1/5	do	.2025	.0014	.0014	.027	.0135	.00
53	June 15	15/100	do	.051	.0013	.0012	.0238	.0136	.00

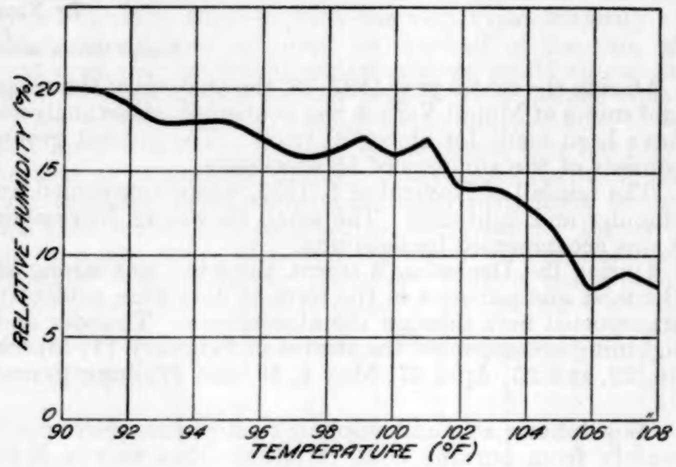
NOTES AND REVIEWS

Relative Humidity With High Summer Temperatures at Boise, Idaho, by GEORGE F. VON ESCHEN.—The relative humidity has always been one of the principal factors in human comfort, and during the past several years has become one of the important factors involved in air conditioning.

For the past 7 years a hygrograph has been exposed in the Weather Bureau instrument shelter on the roof of the Federal Building in Boise. Hourly relative humidity readings have been obtained in the same manner and with the same care as hourly temperature readings. A tabulation of the relative humidity for all hours having temperatures of 90° or higher was made. The results are indicated in the following table and graph.

TABLE 1.—*Percent of relative humidity with temperatures of 90° or higher*

Temperature (°F.)	Average percent of relative humidity					
	May	June	July	August	September	Season
90	12	22	22	19	17	20
91	17	20	21	19	17	20
92	10	20	20	18	17	19
93	16	20	20	16	16	18
94	10	20	19	16	16	18
95	10	17	19	15	12	18
96		19	18	15	15	17
97		15	17	14	14	16
98		15	18	13		16
99		20	19	12		17
100		14	17	13		16
101		18	18	6	15	17
102		17	15	9		14
103			14			14
104		16	12			13
105			11			11
106			8			8
107			9			9
108			8			8
Average	12	20	19	17	16	18



In all, 1,742 hours were considered. As would be expected the humidity generally showed a decrease with increase in temperature and also at the same temperatures as the season progressed. The outstanding exception being the month of May, when unusually low humidities occurred with temperatures of 90° or higher. This condition is explained by the infrequency of the occurrence of these higher temperatures—only 20 hours with temperatures of 90° or higher having occurred during May in the past 7 years—and also by the conclusion that abnormal meteorological conditions must prevail to produce these high temperatures so early in the season. Had more data been available, undoubtedly a more uniform seasonal graph would have resulted. No smoothing of means or weighting of values was attempted.

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[RICHMOND T. ZOCH, in charge of Library]

By AMY P. LESHER

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SOLAR OBSERVATIONS

[Meteorological Research Division, EDGAR W. WOOLARD in charge]

SOLAR RADIATION OBSERVATIONS, JUNE 1938

By CHARLES M. LENNAHAN

Measurements of solar radiant energy received at the surface of the earth are made at eight stations maintained by the Weather Bureau, and at nine cooperating stations maintained by other institutions. The intensity of the total radiation from sun and sky on a horizontal surface is continuously recorded (from sunrise to sunset) at all these stations by self-registering instruments; pyrheliometric measurements of the intensity of direct solar radiation at normal incidence are made at frequent intervals on clear days at three Weather Bureau stations (Washington, D. C., Madison, Wis., Lincoln, Nebr.) and at the Blue Hill Observatory of Harvard University. Occasional observations of sky polarization are taken at the Weather Bureau stations at Washington and Madison.

The geographic coordinates of the stations, and descriptions of the instrumental equipment, station exposures, and methods of observation, together with summaries of the data, obtained up to the end of 1936, will be found in the MONTHLY WEATHER REVIEW, December 1937, pp. 415 to 441; further descriptions of instruments and methods are given in Weather Bureau Circular Q.

Table 1 contains the measurements of the intensity of direct solar radiation at normal incidence, with means and their departures from normal (means based on less than 3 values are in parenthesis). At Madison and Lincoln the observations are made with the Marvin pyrheliometer; at Washington and Blue Hill they are obtained with a recording thermopile, checked by observations with a Marvin pyrheliometer at Washington and with a Smithsonian silver disk pyrheliometer at Blue Hill. The table also gives vapor pressures at 8 a. m. (75th meridian time) and at noon (local mean solar time).

During July 1938 direct solar radiation intensities averaged above normal at Blue Hill, Madison, and Lincoln.

Table 2 contains the average amounts of radiation received daily on a horizontal surface from both sun and sky during each week, their departures from normal and the accumulated departures since the beginning of the year. The values at most of the stations are obtained from the records of the Eppley pyrheliometer recording on either a microammeter or a potentionmeter.

Six stations for which normals exist received an excess of total solar and sky radiation during July 1938. Nine of the stations received a deficiency of total radiation during the month.

Polarization measurements were made on 7 days at Madison giving a mean value of 37.1 percent and a maximum of 56.3 percent on the 28th; both of these values are below the corresponding normals for the month.

TABLE 1.—*Solar radiation intensities during July 1938*

[Gram-calories per minute per square centimeter of normal surface]

WASHINGTON, D. C.

No observations were obtained at Washington due to cloudy weather and instrumental trouble.

MADISON, WIS.

Date	8 a.m. 75th mer. time	Sun's zenith distance 78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon Local mean solar time
		Air mass A. M.					P. M.				
	e	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
July 4	12.68		0.71			1.42					13.13
July 6	13.13					1.13					19.89
July 9	14.60	0.88	.98	1.10	1.26	1.47					15.65
July 11	17.37	.74	.86		1.18	1.40					15.11
July 12	16.20		.86		1.00						18.59
July 14	11.38	.80	.90		1.23	1.41					11.38
July 15	9.47				1.26						10.97
July 18	12.68	.84	.92		1.17	1.37					10.21
July 19	11.81	.65	.74								14.60
July 28	13.13	.78	.91	1.06	1.23						13.61
July 29	12.24					1.33					14.60
Means		.78	.85	(1.01)	1.19	1.36					
Departures		+.08	+.07	+.09	+.12	+.06					

LINCOLN, NEBR.

Date	8 a.m. e	78.7° (5.0)	75.7° (4.0)	70.7° (3.0)	60.0° (2.0)	0.0° (1.0)	60.0° (2.0)	70.7° (3.0)	75.7° (4.0)	78.7° (5.0)	Noon e
July 1	16.79				1.04	1.37					18.59
July 2	17.37					1.36	1.02				18.59
July 4	15.65		0.80	0.94	1.11						10.21
July 5	14.10										
July 8	12.68		.99	1.10	1.26	1.46					10.21
July 9	12.68		.86	1.00	1.17						12.68
July 10	16.20			.84	1.06						12.68
July 11	14.10				1.28						9.83
Means			.88	.97	1.13	1.40	(1.02)				
Departures			+.09	+.05	+.04	+.06	−.05				

BLUE HILL, MASS.

Date	8 a.m. e	78.7° (5.0)	75.7° (4.0)	70.7° (3.0)	60.0° (2.0)	0.0° (1.0)	60.0° (2.0)	70.7° (3.0)	75.7° (4.0)	78.7° (5.0)	Noon e
July 2	14.2					1.32	1.07				12.3
July 3	7.9						1.05				9.9
July 4	8.6						1.33	1.21			9.6
July 5	10.7				1.08	1.23					11.5
July 7	10.3					1.28					10.3
July 8	13.2				.86	1.14	.94				16.4
July 9	15.3					1.26					18.2
July 10	16.9					1.27	1.08				15.3
July 16	11.9			0.96	1.12	1.38					13.2
July 30	18.2					1.33					14.7
July 31	13.7					1.29					14.7
Means				(0.96)	1.02	1.28	1.09	(1.21)			
Departures				+.05	−.03	+.01	+.07	+.28			

TABLE 2.—*Average daily totals of solar radiation (direct+diffuse) received on a horizontal surface*

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Fresno	Fairbanks	Twin Falls	La Jolla	Miami	New Orleans	Riverside	Blue Hill	San Juan	Friday Harbor	Ithaca	Newport
	Gram-calories per square centimeter																
	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
July 2	583	540	642	525	619	760	444	521	586	354	(1)	576	581	659	580		615
July 9	474	611	699	498	420	727	445	586	468	456	(1)	543	458	626	616		549
July 16	391	592	530	484	268	713	538	643	553	480	299	513	318	623	626		342
July 23	363	539	556	510	273	667	530	560	411	475	442	579	368	658	543		473
	Departures of daily totals from normals																
July 2	+69	+6	+45	+52	+153	+46	+1	−75	−6	−137	(1)	−34	0	+61	+5		
July 9	−18	+73	+105	+42	−27	+30	−40	−14	−120	−61	(1)	−47	−34	+26	+41		
July 16	−88	+65	−54	+22	−152	+23	+111	+33	+1	−35	−107	−49	−171	+11	−15		
July 23	−122	+25	0	+39	−147	+4	+85	−8	−47	−37	+59	+33	−93	+61	−60		
	Accumulated departures since Jan. 1																
	−10,686	−2,345	−1,246	+4,095	−630	−1,778	+4,809	−7,576	−3,640	−4,095	+4,144	−4,298	−3,997	+8,468	+8,050		

[1] No record from July 2 to July 18, inclusive, due to instrumental overhauling.

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, U. S. Navy (Ret.), Superintendent, U. S. Naval Observatory. Data furnished by the U. S. Naval Observatory in cooperation with Harvard and Mount Wilson Observatories. The difference in longitude is measured from the central meridian, positive west. The north latitude is positive. Areas are corrected for foreshortening and are expressed in millionths of the sun's visible hemisphere. The total area for each day includes spots and groups]

Date	Eastern standard time		Mt. Wilson group No.	Heliographic			Area		Spot count	Observatory
				Diff. in longitude	Longitude	Latitude	Spot or group	Total for each day		
1938	h	m		°	°	°				
July 1	11	26	5968	-80.0	136.8	-7.0	145	....	1	U. S. Naval.
			5962	-21.0	195.8	-7.0	182	....	1	
			5957	-12.0	204.8	-10.0	436	....	58	
			5961	-5.0	211.8	-21.0	485	....	37	
			5967	-1.0	215.8	-7.5	24	....	2	
			5956	-0.5	216.3	+29.0	24	....	4	
			5956	+7.0	223.8	+26.0	36	....	6	
			5960	+24.5	241.3	+4.0	16	....	3	
			5959	+30.0	246.8	-7.0	24	1,372	8	
July 2	11	30	5971	-74.0	129.5	+12.0	97	....	1	Do.
			5968	-66.0	137.5	-7.0	97	....	2	
			5970	-60.0	143.5	+14.0	36	....	4	
			5962	-8.0	195.5	-9.0	145	....	1	
			5957	+2.0	205.5	-10.5	436	....	45	
			5961	+8.0	211.5	-21.5	436	....	28	
			5967	+13.0	216.5	-7.5	24	....	1	
			5956	+13.0	216.5	+28.0	36	....	5	
			5956	+21.0	224.5	+25.0	48	....	5	
			5959	+43.0	246.5	-7.0	24	....	2	
			5969	+58.0	261.5	-8.0	12	1,391	1	
Suly 3	11	35	5971	-61.0	129.2	+12.0	97	....	1	Do.
			5968	-55.0	135.2	-7.0	97	....	6	
			5970	-47.5	142.7	+13.0	388	....	15	
			5962	+7.0	197.2	-7.0	145	....	2	
			5957	+15.0	205.2	-10.5	339	....	30	
			5961	+21.0	211.2	-21.5	291	....	25	
			5956	+30.0	220.2	+26.0	97	....	15	
			5959	+58.0	248.2	-7.5	24	....	1	
			5969	+70.0	260.2	-9.0	97	1,575	2	
July 4	12	3	5973	-80.0	96.7	-14.5	145	....	4	Do.
			5972	-80.0	96.7	+13.0	194	....	3	
			5971	-48.0	128.7	+12.0	48	....	2	
			5968	-42.5	134.2	-7.0	97	....	6	
			5970	-35.0	141.7	+12.5	630	....	28	
			5962	+20.0	196.7	-7.0	121	....	2	
			5957	+30.0	206.7	-10.5	485	....	33	
			5961	+35.0	211.7	-21.5	242	....	18	
			5956	+42.0	218.7	+27.0	145	2,107	15	
July 5	11	3	5976	-78.0	86.1	-15.0	48	....	4	Do.
			5972	-68.0	96.1	+13.5	291	....	4	
			5973	-67.0	97.1	-14.0	533	....	16	
			5975	-50.0	114.1	+12.0	6	....	5	
			5971	-36.0	128.1	+12.5	73	....	2	
			5968	-30.0	134.1	-7.0	97	....	6	
			5970	-22.0	142.1	+12.0	970	....	18	
			5962	+32.0	196.1	-7.0	194	....	1	
			5957	+41.0	205.1	-11.0	436	....	23	
			5961	+47.0	211.1	-22.0	339	....	8	
			5956	+54.0	218.1	+27.0	485	3,472	10	
July 6	11	8	5978	-84.0	66.8	-17.0	776	....	5	Do.
			5977	-77.0	73.8	+15.0	24	....	2	
			5976	-64.0	86.8	-16.0	61	....	3	
			5973	-55.0	95.8	-14.0	776	....	40	
			5972	-55.0	95.8	+14.0	242	....	6	
			5975	-39.0	111.8	+13.0	109	....	9	
			5971	-22.0	128.8	+11.5	48	....	4	
			5968	-15.0	135.8	-8.0	73	....	7	
			5970	-9.0	141.8	+12.0	921	....	31	
			5974	+12.0	162.8	+17.5	48	....	5	
			5962	+46.0	196.8	-7.0	145	....	1	
			5957	+55.0	205.8	-11.5	388	....	28	
			5961	+60.0	210.8	-22.0	339	....	10	
			5956	+65.0	215.8	+27.0	485	4,435	15	
July 7	10	47	5978	-68.0	69.7	-17.5	679	....	5	Do.
			5977	-61.0	76.7	+16.0	24	....	2	
			5976	-50.0	87.7	-16.0	145	....	10	
			5972	-41.0	96.7	+15.0	194	....	6	
			5973	-40.0	97.7	-13.0	776	....	66	
			5975	-26.0	111.7	+13.0	145	....	19	
			5971	-9.0	128.7	+12.0	24	....	2	
			5968	-1.0	136.7	-8.0	73	....	6	
			5970	+4.5	142.2	+13.0	873	....	22	
			5974	+26.0	163.7	+17.0	36	....	5	
			5962	+60.0	197.7	-7.0	145	....	2	
			5957	+70.0	207.7	-13.0	291	....	10	
			5961	+75.0	212.7	-23.0	242	....	2	
			5956	+79.0	216.7	+27.0	339	3,986	3	
July 8	11	38	5982	-81.0	43.0	-11.0	194	....	2	Do.
			5978	-53.0	71.0	-17.5	485	....	4	
			5977	-48.0	76.0	+15.0	24	....	1	
			5979	-38.0	86.0	+19.0	12	....	2	
			5976	-36.0	88.0	-15.0	97	....	8	
			5980	-35.0	89.0	+15.0	6	....	1	
			5972	-27.0	97.0	+15.0	194	....	3	
			5973	-26.0	98.0	-13.0	873	....	45	
			5975	-11.0	113.0	+14.5	97	....	18	
			5971	+4.0	128.0	+15.0	6	....	1	
			5968	+13.0	137.0	-7.0	73	....	3	
			5970	+17.0	141.0	+14.0	776	....	18	
			5974	+40.0	164.0	+19.0	48	....	4	
			5981	+65.0	180.0	-21.0	6	....	2	
			5962	+75.0	199.0	-6.0	145	....	1	
			5961	+85.0	209.0	-21.0	97	3,133	1	

Positions and areas of sun spots—Continued

Date	Eastern standard time		Mt. Wilson group No.	Heliographic			Area		Spot count	Observatory
				Diff. in longitude	Longitude	Latitude	Spot or group	Total for each day		
1938	h	m		°	°	°				
July 9	11	24	5985	-86.0	24.9	+5.0	485	....	1	U. S. Naval.
			5984	-84.0	26.9	+7.0	48	....	3	
			5983	-78.0	32.9	+9.0	194	....	3	
			5982	-71.0	39.9	-11.0	873	....	20	
			5981	-49.0	61.9	-21.0	6	....	2	
			5978	-41.0	69.9	-17.0	485	....	15	
			5977	-32.5	78.4	+16.0	6	....	2	
			5976	-24.0	86.9	-13.0	73	....	10	
			5973	-14.0	96.9	-14.0	1,212	....	60	
			5972	-14.0	96.9	+15.0	242	....	5	
			5975	+2.0	112.9	+15.0	97	....	18	
			5968	+26.5	137.4	-7.0	73	....	2	
			5970	+30.0	140.9	+15.0	727	....	25	
			5974	+53.0	163.9	+19.0	12	4,533	2	
July 10	11	11	5986	-71.0	26.8	-15.0	12	....	1	Do.
			5985	-70.5	27.3	+5.0	291	....	1	
			5984	-65.0	32.8	+7.0	97	....	7	
			5983	-65.0	32.8	+11.0	97	....	11	
			5982	-59.5	38.3	-11.0	1,454	....	40	
			5978	-29.0	68.8	-17.0	485	....	20	
			5988	-20.0	77.8	-27.0	73	....	6	
			5976	-11.0	86.8	-13.0	24	....	2	
			5972	-2.0	95.8	+16.0	388	....	25	
			5973	0.0	97.8	-13.5	1,309	....	90	
			5975	+12.0	109.8	+15.0	48	....	5	
			5975	+19.0	116.8	+14.0	36	....	5	
			5968	+40.0	137.8	-7.0	6	....	5	
			5970	+44.5	142.3	+13.0	582	4,902	15	
July 11	11	15	5986	-59.0	25.5	-15.0	16	....	1	Do.
			5985	-55.0	29.5	+4.0	291	....	1	
			5983	-50.0	34.5	+11.0	97	....	10	
			5984	-49.0	35.5	+7.0	97	....	10	
			5982	-46.0	38.5	-13.0	1,454	....	49	
			5978	-15.5	69.0	-18.0	339	....	30	
			5988	-7.5	77.0	-27.0	97	....	10	
			5972	+13.0	97.5	+16.0	218	....	28	
			5973	+14.0	98.5	-13.5	1,454	....	96	
			5989	+14.0	98.5	+11.0	73	....	7	
			5970	+57.0	141.5	+12.0	485	4,621	17	
July 12	13	22	5990	-86.0	344.1	+4.0	97	....	1	Do.
			5986	-44.0	26.1	-15.0	24	....	1	
			5985	-41.0	29.1	+4.0	242	....	1	
			5984	-35.0	35.1	+7.0	48	....	10	
			5983	-34.0	36.1	+11.0	121	....	11	
			5982	-32.0	38.1	-14.0	1,842	....	80	
			5978	-1.0	69.1	-18.0	339	....	32	
			5988	+10.0	80.1	-26.0	48	....	6	
			5972	+27.5	97.6	+17.0	121	....	13	
			5973	+28.0	98.1	-13.5	1,454	....	60	
			5989	+28.5	98.6	+11.0	73	....	9	
			5970	+72.0	142.1	+12.0	388	4,797	10	
July 13	11	16	5990	-74.0	344.1	+5.0	194	....	1	Do.
			5986	-32.0	26.1	-15.0	12	....	1	
			5985	-29.0	29.1	+4.5	242	....	1	
			5984	-23.0	35.1	+8.0	97	....	10	
			5983	-21.5	36.6	+11.0	97	....	9	
			5982	-20.0	38.1	-14.0	2,182	....	100	
			5991	-12.5	45.6	+22.0	36	....	7	
			5981	+4.0	62.1	-21.0	12	....	5	
			5978	+11.0	69.1	-19.0	291	....	22	
			5988	+22.0	80.1	-26.0	6	....	1	
			5989	+40.0	98.1	+12.0	36	....	6	
			5972	+40.0	98.1	+16.0	85	....	6	
			5973	+40.0	98.1	-14.0	1,454	4,744	76	
July 14	13	59	5993	-60.0	343.3	-18.0	97	....	9	Do.
			5990	-60.0	343.3	+5.0	121	....	2	
			5986	-19.0	24.3	-15.0	12	....	2	
			5985	-13.0	30.3	+4.5	218	....	3	
			5982	-5.0	38.3	-14.0	2,473	....	100	
			5983	-4.0	39.3	+11.5	36	....	5	
			5984	-3.0	40.3	+7.0	73	....	7	
			5991	+4.0	47.3	+23.0	24	....	2	
			5981	+27.0	70.3	-19.0	73	....	22	
			5978	+29.0	72.3	-17.0	121	....	16	
			5988	+37.0	80.3	-26.0	6	....	1	
			5973	+54.0	97.3	-14.0	1,309	....	46	
			5972	+55.0	98.3	+16.0	73	....	8	
			5989	+55.0	98.3	+12.0	24	4,660	2	
July 15	11	56	5993	-48.0	343.2	-17.5	145	....	9	Do.
			5990	-48.0	343.2	+5.0	145	....	2	
			5992	-41.0	350.2	+11.0	24	....	3	
			5996	-31.0	0.2	-28.0	12	....	4	
			5985	-1.0	30.2	+3.5	242	....	3	
			5982	+8.0	39.2	-14.0	2,424	....	105	
			5984	+8.0	39.2	+7.0	48	....	9	
			5995	+11.0	42.2	+19.0	24	....	4	
			5991	+16.0	47.2	+24.0	6	....	1	
			5981	+35.0	66.2	-21.0	12	....	1	
			5978	+40.0	71.2	-16.0	97	....	8	
			5994	+49.5	80.7	+10.5	48	....	5	
			5972	+56.0	87.2	+19.0	73	....	5	
			5973	+67.0	98.2	-14.0	970	....	30	
			5989	+68.5	99.7	+14.0	24	4,294	3	

Positions and areas of sun spots—Continued

Date	Eastern standard time		Mt. Wilson group No.	Heliographic			Area		Spot count	Observatory
				Diff. in longitude	Longitude	Latitude	Spot or group	Total for each day		
1938	h	m		°	°	°				
July 16	11	9	5998	−37.0	341.4	+18.5	12		2	U. S. Naval.
			5993	−34.0	344.4	−17.0	109		15	
			5990	−34.0	344.4	+5.5	145		2	
			5992	−28.0	350.4	+11.0	24		5	
			5996	−20.0	358.4	−26.5	36		6	
			5985	+12.0	30.4	+4.0	206		3	
			5983	+18.0	36.4	+10.0	12		2	
			5982	+22.0	40.4	−14.0	2,133		72	
			5995	+25.5	43.9	+19.0	36		4	
			5978	+52.0	70.4	−15.0	48		3	
			5994	+66.0	84.4	+10.0	73		5	
			5972	+68.0	86.4	+19.0	97		4	
			5973	+76.0	94.4	−15.0	582	3,513	7	
July 17	11	15	6000	−88.0	277.1	+16.0	194		1	Do.
			5999	−50.0	315.1	+7.0	73		10	
			5993	−21.0	344.1	−17.0	61		8	
			5990	−20.0	345.1	+5.0	145		1	
			5996	−9.0	356.1	−26.0	24		4	
			5985	+26.0	31.1	+4.0	218		6	
			5982	+35.0	40.1	−14.0	2,036		70	
			5995	+39.0	44.1	+20.0	61		20	
			5978	+68.0	73.1	−15.0	48		2	
			5994	+78.0	83.1	+12.0	24	2,884	1	
July 18	11	14	6000	−74.0	277.9	+15.5	242		2	Do.
			5999	−37.0	314.9	+7.0	48		6	
			5998	−12.0	339.9	+20.0	12		3	
			5990	−7.0	344.9	+5.0	97		1	
			5993	−4.0	347.9	−17.0	12		3	
			5992	+3.0	354.9	+12.0	12		2	
			5996	+5.5	357.4	−26.0	16		2	
			5985	+39.0	30.9	+4.0	218		3	
			5982	+48.0	39.9	−14.0	1,939		65	
			5995	+51.0	42.9	+20.0	242	2,838	22	
July 19	11	10	6005	−78.0	260.7	−11.0	121		2	Do.
			6004	−65.0	273.7	+5.0	12		4	
			6000	−60.0	278.7	+15.0	291		3	
			6003	−55.0	283.7	−7.0	6		2	
			5999	−22.0	316.7	+7.0	24		5	
			5990	+7.5	346.2	+5.0	121		2	
			5993	+10.0	348.7	−17.0	6		2	
			5992	+16.0	354.7	+12.5	36		6	
			5985	+51.0	29.7	+4.0	206		1	
			5982	+63.0	41.7	−15.0	2,133		70	
			5995	+65.5	44.2	+20.0	97	3,053	10	
July 20	11	35	6007	−85.0	240.2	−20.0	48		2	Do.
			6005	−63.0	262.2	−11.0	61		2	
			6004	−52.0	273.2	+7.0	18		2	
			6000	−47.0	278.2	+15.0	242		1	
			6003	−40.0	285.2	−7.5	97		9	
			5999	−7.0	318.2	+9.0	12		3	
			6001	+16.0	341.2	+9.5	61		4	
			5990	+21.0	346.2	+5.0	97		4	
			5992	+29.0	354.2	+12.0	24		5	
			6002	+35.0	.2	+5.5	24		3	
			5985	+65.0	30.2	+4.5	242		1	
			5982	+76.0	41.2	−15.0	3,103	4,029	40	
July 21	14	15	6012	−67.0	243.6	+3.0	48		4	Mt. Wilson.
			6007	−66.0	244.6	−18.5	97		5	
			6005	−50.0	260.6	−10.0	97		1	
			6011	−48.0	262.6	+21.5	97		17	
			6004	−38.5	272.1	+7.0	36		6	
			6000	−34.5	276.1	+17.0	242		3	
			6003	−25.0	285.6	−7.0	73		10	
			6001	+32.0	342.6	+10.0	194		17	
			5990	+36.0	346.6	+7.0	61		1	
			5985	+80.0	30.6	+6.5	145	1,090	1	
July 22	13	11	6014	−74.0	223.9	−10.0	194		3	U. S. Naval.
			6007	−56.0	241.9	−18.0	48		5	
			6012	−54.0	243.9	+3.0	73		12	
			6005	−38.0	259.9	−10.0	73		2	
			6011	−35.0	262.9	+21.0	97		20	
			6000	−31.0	266.9	+18.0	48		14	
			6000	−21.0	276.9	+17.0	242		7	
			6004	−27.0	270.9	+7.0	48		8	
			6003	−13.0	284.9	−6.0	97		15	
			6013	−7.0	290.9	+6.0	24		5	
			6001	+44.0	341.9	+8.0	97		14	
			5990	+48.0	345.9	+7.0	97		2	
			5992	+57.0	354.9	+12.0	36	1,174	5	
July 23	9	50	6017	−85.0	201.5	−6.0	194		1	Mt. Wilson.
			6016	−76.0	210.5	−21.0	485		10	
			6014	−63.0	223.5	−8.0	242		8	
			6007	−43.0	243.5	−17.0	73		11	
			6012	−40.5	246.0	+3.0	97		14	
			6005	−26.0	260.5	−9.5	73		1	
			6011	−22.0	264.5	+22.0	388		25	
			6000	−18.0	268.5	+19.0	48		22	
			6000	−9.0	277.5	+17.5	291			
			6004	−13.0	273.5	+7.0	36		6	
			6015	+1.0	287.5	+26.0	24		3	
			6003	+1.0	287.5	−6.0	121		18	
			6013	+7.0	293.5	+7.0	194		22	
			6010	+41.0	327.5	+21.0	12		1	
			6001	+58.0	344.5	+8.0	73		11	
			5990	+61.0	347.5	+6.5	85		3	
			5992	+71.0	357.5	+12.0	24	2,460	4	
July 24	13	1	6017	−71.0	200.5	−7.0	194		6	Mt. Wilson.
			6016	−64.0	207.5	−21.0	485		15	
			6014	−48.0	223.5	−7.0	194		5	
			6007	−29.0	242.5	−18.0	48		12	
			6012	−25.0	246.5	+4.0	97		10	
			6005	−11.0	260.5	−9.0	73		1	
			6011	−5.0	266.5	+21.0	242		14	
			6000	−4.0	267.5	+19.0	48		9	
			6000	+3.5	275.0	+18.0	242			
			6004	+2.0	273.5	+7.0	61		5	
			6003	+15.0	286.5	−7.0	121		10	
			6013	+19.0	290.5	+7.0	291		12	
			6010	+52.0	323.5	+22.0	36		3	
			6001	+69.0	340.5	+7.5	48		5	
			5990	+78.0	349.5	+6.0	61	2,241	1	
July 25	13	32	6017	−60.0	198.0	−9.5	388		4	U. S. Naval.
			6017	−54.5	203.5	−9.0	73		13	
			6016	−59.0	199.0	−26.0	97		20	
			6016	−48.0	210.0	−22.0	485		24	
			6014	−32.0	226.0	−9.0	170		6	
			6007	−13.0	245.0	−19.0	24		6	
			6012	−10.0	248.0	+3.0	145		24	
			6005	+3.0	261.0	−10.0	48		2	
			6011	+3.0	261.0	+21.0	121		18	
			6000	+12.0	270.0	+19.0	73		13	
			6000	+19.0	277.0	+18.0	145		11	
			6018	+14.0	272.0	−17.0	6		2	
			6004	+17.0	275.0	+6.0	24		3	
			6015	+27.0	285.0	+25.0	36		9	
			6003	+30.0	288.0	−7.0	145		20	
			6013	+35.0	293.0	+7.0	582		22	
			6001	+80.0	338.0	+8.0	6	2,568	1	
July 26	14	4	6017	−47.0	197.5	−9.5	291		3	Do.
			6017	−39.0	205.5	−9.0	48		4	
			6016	−45.0	199.5	−26.0	194		14	
			6016	−35.0	209.5	−22.0	727		34	
			6014	−19.0	225.5	−9.0	97		5	
			6007	+2.0	246.5	−19.0	24		7	
			6012	+4.0	248.5	+3.0	121		17	
			6005	+17.0	261.5	−10.0	48		4	
			6011	+22.0	266.5	+20.0	73		12	
			6000	+32.0	276.5	+17.0	85		10	
			6015	+40.0	284.5	+26.0	36		3	
			6003	+45.0	289.5	−7.5	242		31	
			6013	+48.0	292.5	+7.0	582	2,568	22	
July 27	10	55	6017	−35.0	198.0	−9.0	303		7	Do.
			6017	−27.0	206.0	−9.0	36		9	
			6016	−33.0	200.0	−27.0	97		12	
			6016	−22.0	211.0	−22.5	533		40	
			6014	−9.0	224.0	−9.0	97		7	
			6012	+18.0	251.0	+3.0	97		6	
			6005	+29.0	262.0	−10.5	36		2	
			6011	+34.0	267.0	+20.0	121		13	
			6000	+45.0	278.0	+16.0	73		7	
			6015	+50.0	283.0	+25.0	6		1	
			6003	+55.0	288.0	−8.0	339		28	
			6013	+59.0	292.0	+7.0	533	2,271	20	
July 28	10	58	6022	−80.0	139.8	+18.0	6		1	Do.
			6020	−32.0	187.8	+1.0	12		3	
			6017	−21.0	198.8	−9.0	291		28	
			6017	−13.0	206.8	−9.0	48		5	
			6016	−19.0	200.8	−16.0	97		25	
			6016	−9.0	210.8	−22.0	485		30	
			6014	+6.0	225.8	−8.5	73		9	
			6012	+29.0	248.8	+3.0	145		17	
			6005	+41.0	260.8	−10.0	48		2	
			6011	+48.0	267.8	+20.0	73		11	
			6000	+56.0	275.8	+16.0	24		8	
			6003	+70.0	289.8	−9.0	485		13	
			6013	+74.0	293.8	+6.0	533	2,320	8	
July 29	11	48	6022	−68.0	138.1	+18.0	6		2	Do.
			6020	−15.0	191.1	+3.0	24		5	
			6017	−7.0	199.1	−7.0	315		30	
			6017	+2.0	208.1	−7.0	24		2	
			6016	−4.0	202.1	−22.0	48		20	
			6016	+6.0	212.1	−20.0	436		28	
			6019	+15.0	221.1	+25.0	24		3	
			6014	+20.0	226.1	−7.0	73		7	
			6012	+48.0	254.1	+4.0	170		20	
			6011	+55.0	261.1	+21.0	12		4	
			6005	+57.0	263.1	−10.0	36		2	
			6000	+65.0	271.1	+19.0	12		2	
			6013	+85.0	291.1	+7.0	194	1,374	2	
July 30	11	14	6022	−56.0	137.2	+19.0	6		1	Do.
			6020	−1.0	192.2	+3.0	6		3	
			6017	+8.0	201.2	−7.0	412		21	
			6017	+15.0	208.2	−7.0	48		28	
			6016	+7.0	200.2	−24.0	48		27	
			6016	+18.0	211.2	−21.0	436		22	
			6023	+21.0	214.2	+6.0	12		2	
			6014	+33.0	226.2	−8.0	12		1	
			6012	+60.0	253.2	+3.0	291		17	
			6005	+69.0	262.2	−10.5	24	1,295	1	
July 31	12	34	6025	−80.0	99.2	−2.0	97		3	Do.
			6024	−73.0	106.2	−12.0	121		1	
			(*)	−63.0	116.2	−16.0	6		1	
			6022	−41.0	138.2	+19.0	12		2	
			6017	+22.0	201.2	−7.0	339		40	
			6016	+30.0	209.2	−21.0	291		30	
			6023	+33.0	212.2	+7.0	12		4	
			6014	+47.0	226.2	−7.0	48		1	
			6012	+75.0	254.2	+3.0	436	1,362	14	

Mean daily area for 31 days =2,937. *** Not numbered.**

PROVISIONAL SUNSPOT RELATIVE NUMBERS FOR JULY 1938

[Dependent alone on observations at Zurich]

[Data furnished through the courtesy of Prof. W. Brunner, Eidgen. Sternwarte, Zurich, Switzerland]

July 1: Great eruptive prominence on west limb.

July 3: Middle large bright chromospheric eruption at $13^h 30^m$ to $13^h 38^m$ U. T., east.

July 4: Middle large bright chromospheric eruptions (2 centers) at $7^h 10^m$ to $7^h 20^m$ and $12^h 00^m$ to $12^h 35^m$, west.

July 5: Middle bright chromospheric eruption at $13^h 45^m$ to $14^h 10^m$, west.

July 10: Large bright chromospheric eruption at $15^h 32^m$ to $15^h 37^m$, central zone.

July 28: Great eruptive prominence on west limb at $13^h 58^m$ to $15^h 35^m$.

July 1938	Relative numbers	July 1938	Relative numbers	July 1938	Relative numbers
1	*ad* 119	11	205	21	147
2	*Eac* —	12	*a* 211	22	*Ec* 118
3	*a* 157	13	229	23	*Macd* 157
4	*dd* 151	14	*Ebc* 208	24	*aad* —
5	141	15	*a* 200	25	202
6	*Ecd* 184	16	173	26	*a* 179
7	*b* 175	17	161	27	156
8	*d* 186	18	*d* 148	28	*a* 151
9	*d* 175	19	*Eac* 151	29	*aa* 151
10	*ab* 183	20	*EMcc* 153	30	*a* 139
				31	109

Mean, 29 days = 166.2

a = Passage of an average-sized group through the central meridian.
b = Passage of a large group or spot through the central meridian.
c = New formation of a group developing into a middle-sized or large center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central circle zone.
d = Entrance of a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[Aerological Division, D. M. LITTLE in Charge]

By B. FRANCIS DASHIELL

The mean free-air data for the month of July 1938, given in table 1, are based on a total of 366 airplane and radiometeorograph observations. They include the basic meteorological elements of barometric pressure (P), temperature (T), and relative humidity (R. H.), recorded at certain geometric heights. The reduced number of observations obtained in July was unavoidable because of the hiatus that existed when certain airplane stations were discontinued and radiometeorograph observations substituted therefor.

These "means" are computed by the customary method of differences, but are omitted whenever less than 15 observations have been made at the surface and less than 5 at a standard height. At those levels, however, which fall within the limits of the monthly vertical range of the tropopause, at least 15 observations are necessary. For further details, see "Aerological Observations," in the January 1938, issue of the MONTHLY WEATHER REVIEW.

Chart I, published elsewhere in this REVIEW, shows the departure of mean *surface* temperature from the normal. The temperature was slightly in excess of normal over most of the country, particularly so in the far Northwest, where it was decidedly warm (+6° F.), and in the Central Plains States, where it was moderately warm (+4° F.). In the Southeast, western Texas, and New Mexico, the mean temperature was slightly below normal (−2° F.).

Free-air mean temperatures at all levels *above* the surface, for all but one station in the United States, ranged seasonally higher than during the preceding month of June. The greatest positive differences in mean free-air temperatures for July over June were noted at San Diego, Calif., at 1 kilometer (5.7° C.); over Spokane, Wash., at 1.5 and 2 kilometers (5.4° C. and 5.2° C., respectively); over Seattle, Wash., at 2.5, 3, and 4 kilometers (4.9° C., 4.5° C., and 4.2° C., respectively): and over Washington, D. C., at 5 kilometers (3.2° C.). The only negative free-air temperature differences for July over June, occurred over El Paso, Tex., at 1.5, 2, 2.5, and 3 kilometers (0.9° C., 1.1° C., 1.0° C., and 0.9° C., respectively). July temperatures were slightly lower, however, than during the corresponding month in 1937, except over Seattle, Wash., where July 1938 averaged at least 3° C. warmer at all levels.

Temperatures were highest over the Southeast at 0.5 kilometer, and remained high also over the Southern Rocky Mountain States and California at all other levels. The lowest mean free-air temperatures occurred over the North Atlantic States and the far Northwest at all levels. Actually, the highest temperatures for the current month were recorded over Pensacola, Fla., at 0.5 kilometers; over San Diego, Calif., and Spokane, Wash., at 1 kilometer; over Salt Lake City, Utah, at 1.5, 2 and 2.5 kilometers; over San Diego, Calif., and Salt Lake City, Utah, at 3 kilometers; over San Diego, Calif., at 4 kilometers; and over El Paso, Tex., at 5 kilometers. The highest mean temperature of the month (23.6° C.) occurred over Pensacola, Fla., at 0.5 kilometer, while the lowest of the month (−7.8° C.) was recorded over Lakehurst, N. J., at 5 kilometers. Also, low temperatures were recorded over Lakehurst, N. J., and Seattle, Wash., at all levels above 0.5 kilometer.

Isobaric charts, prepared from the mean barometric pressures in millibars, as given in table 1, show that in July pressure was high over the Southeast and far Northwest up to 2 kilometers, and above that level over the Southern States. At 2.5 and 3.0 kilometers pressures were uniformly distributed in a belt across the central United States, extending from the Atlantic to the Pacific. During July mean pressures varied but little from those recorded in June, except they were somewhat greater in the lower levels, and definitely so at 4 and 5 kilometers. A slight statistical center of low atmospheric pressure existed in the lower levels over Norfolk, Va., but shifted northward to Lakehurst, N. J., and then to New England at the higher levels.

The distribution of free-air relative humidity (table 1) varied considerably from that noted during the preceding month. The humidity at all levels was definitely in excess of that observed in June, and also higher than during the corresponding month of 1937, particularly at the upper levels. The relative humidity was greatest in the lower levels over Pensacola, Fla., and above 3 kilometers at El Paso, Tex. Lower humidities prevailed over Seattle and Spokane, Wash., and southern California, at all levels, while moderately high humidities occurred over the North Atlantic States.

At 3 kilometers a 65-percent relative humidity existed over the central, southeastern, and southern portions of the country. This condition existed generally up to 4 and 5 kilometers, and then increased slightly in value over the Southwestern States, to more than 70 percent at El Paso, Tex., at 5 kilometers.

Free-air resultant winds, based on pilot-balloon observations made near 5 a. m. (75th meridian time) during the month of July, are shown in table 2. Upper-air winds for July showed that the greatest departures from normal directions were located in the extreme southeastern portion of the country, notably over Pensacola and Key West, Fla. During the preceding month the greatest departures had been observed at Seattle, Wash., and Medford, Oreg., but the winds at those stations for July, however, showed nearly normal conditions with one or two exceptions. Other stations reporting moderate departures in direction were: Atlanta, Ga., Washington, D. C., Sault Ste. Marie, Mich., Houston, Tex., and Albuquerque, N. Mex.

Of all the upper-air winds recorded in July, 44 percent were from an easterly direction at the surface. At 1 kilometer, however, only 5 percent were easterly, but this quickly increased again to 21 percent easterly at 2 kilometers, and even at 5 kilometers 20 percent of the observations had an easterly component. Fifteen stations obtained the required number of observations at 5 kilometers during July, while only one failed to reach 3 kilometers.

Pensacola, Fla., showed the widest departures from normal resultant directions in July. These directions were: 217° at the surface; 223° at 0.5 kilometer; 192° at 1 kilometer; 186° at 1.5 kilometers; 137° at 2 kilometers; 140° at 2.5 kilometers; and 39° at 3 kilometers, as compared to the normal directions of 296°, 265°, 251°, 235°, 224°, 222°, and 220°, respectively. The current directions were all south of normal (when rotated counterclockwise), and at 3 kilometers the resultant wind direction reached a position opposite to the normal. At Key West, Fla., entirely reversed conditions obtained, for it was noted that the departures at all levels were north of normal (when rotated clockwise). Wide variations in departure occurred over Key West, Fla., and the differences between the current month and its normal were: 10°, 6°, 11°, 15°, 30°, 36°, 42°, 118°, and 142°, from the surface to 5 kilometers, respectively.

The outstanding differences between the July resultant wind directions and their normals for each level over the United States were: 120° north of normal at the surface (when rotated in a clockwise direction) at Sault Ste. Marie, Mich.; 65° south of normal (counterclockwise), also over Sault Ste. Marie, Mich.; 69° north of normal over Fargo, N. Dak.; 49° south of normal over Pensacola, Fla.; 144° south over Medford, Oreg.; 82° south over Pensacola, Fla.; directly opposite the normal, also over Pensacola, Fla.; and 118° and 142° north of normal over Key West, Fla.; all at the surface, 0.5, 1.0, 1.5, 2.0, 2.5, 3, 4, and 5 kilometers, respectively.

St. Louis, Mo., Omaha, Nebr., and Chicago, Ill., all showed the smallest wind direction departures, and at no level over St. Louis, Mo., was the departure difference more than 7°. Pensacola, Fla., Washington, D. C., Newark, N. J., and Detroit, Mich., showed southerly departures at all levels, when rotated counterclockwise from normal, while Key West, Fla., and Houston, Tex., showed northerly departures, when rotated clockwise. Atlanta, Ga., recorded large southerly departure differences which gradually decreased up to 2 kilometers, and then small northerly departure differences that increased in amount steadily up to 5 kilometers. These interesting departure differences were: −42°, −48°, −35°, −20°, −1°, +10°, +64°, +62°, and +76°, reading from the surface to 5 kilometers, respectively.

During July small departures in resultant wind velocities were noted in the lower levels over the United States, but larger departures occurred at the higher levels. Over Medford, Oreg., less-than-normal, or negative, differences of 2.6 and 5.0 m. p. s. were observed at 4 and 5 kilometers, respectively; over Newark, N. J., a positive difference of 3.5 m. p. s. at 4 kilometers; and over Spokane, Wash., negative differences of 3.0 and 3.5 m. p. s. at 4 and 5 kilometers, respectively. Over Pensacola, Fla., all variations in resultant wind velocities for July were greater than normal, but over Key West, Fla., where the departures in direction were the opposite to those recorded at Pensacola, Fla., the wind velocity departures were less than normal at all levels.

Table 3 shows the maximum free-air wind velocities recorded in July. The highest velocity occurred over Las Vegas, Nev., where the wind speed reached 52.2 m. p. s. (117 miles per hour) from the SSW on the 30th at 19.8 kilometers. Wind velocities of 46.4, 42.4 and 40.0 m. p. s. were recorded at Sault Ste. Marie, Mich., Modena, Utah, and Richmond, Va., respectively, at levels higher than 7 kilometers.

TABLE 1.—*Mean free-air barometric pressure (P) in mb., temperature (T) in °C., and relative humidities (R. H.), in percent, obtained by airplanes and radiometeorographs during July 1938*

Stations	Altitude (meters) m. s. l.													
	Surface				500			1,000			1,500			
	Number of obs.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	
Billings, Mont.[1] (1,090 m)	31	893	17.5	70	----	----	----	----	----	----	852	19.2	54	
Cheyenne, Wyo.[1] (1,873 m)	31	816	14.0	72	----	----	----	----	----	----	----	----	----	
Chicago, Ill.[1] (187 m)	31	992	19.4	87	957	21.7	68	904	19.5	67	852	16.4	67	
Coco Solo, C. Z.[2] (15 m)	27	1,009	24.9	93	955	23.3	87	902	20.4	86	851	17.9	80	
El Paso, Tex.[1] (1,193 m)	21	884	22.0	64	----	----	----	----	----	----	853	22.0	59	
Lakehurst, N. J.[2] (39 m)	20	1,011	19.4	91	958	21.6	59	903	18.0	62	851	13.5	72	
Norfolk, Va.[2] (10 m)	26	1,017	22.8	91	962	23.1	69	908	20.4	68	856	16.9	71	
Pearl Harbor, T. H.[2] (6 m)	31	1,016	23.2	81	960	21.7	78	906	18.3	85	854	16.3	75	
Pensacola, Fla.[2] (13 m)	29	1,016	24.2	94	960	23.6	86	907	20.6	78	856	17.5	76	
St. Thomas, V. I.[2] (8 m)	31	1,017	27.1	75	962	22.0	86	908	18.7	86	856	15.8	82	
Salt Lake City, Utah[1] (1,288 m)	31	872	18.2	54	----	----	----	----	----	----	852	22.8	40	
San Diego, Calif.[2] (10 m)	30	1,014	18.0	86	958	15.2	91	904	22.5	49	853	22.4	37	
Seattle, Wash.[2] (10 m)	24	1,018	20.2	61	962	16.0	72	907	16.4	57	855	15.1	48	
Spokane, Wash.[1] (597)	31	945	17.9	58	----	----	----	902	22.5	38	852	20.1	36	
*Washington, D. C.[2] (13 m)	30	1,015	21.5	87	958	20.8	75	905	18.7	73	852	15.7	74	

Stations	2,000			2,500			3,000			4,000			5,000		
	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.
Billings, Mont.[1] (1,090 m)	803	16.6	51	758	13.1	53	713	9.4	57	632	2.4	58	557	−4.7	56
Cheyenne, Wyo.[1] (1,873 m)	804	16.4	62	758	15.2	56	714	11.9	55	633	4.2	61	559	−4.2	67
Chicago, Ill.[1] (187 m)	804	13.6	67	757	10.7	62	713	7.9	58	631	2.1	52	557	−4.4	51
Coco Solo, C. Z.[2] (15 m)	803	15.4	77	756	13.5	66	713	11.1	59	630	4.5	68	558	−1.2	65
El Paso, Tex.[1] (1,193 m)	805	19.2	62	760	15.9	64	716	12.4	69	634	5.3	77	561	−1.3	72
Lakehurst, N. J.[2] (39 m)	802	9.8	70	755	7.3	56	710	4.6	49	627	−1.3	45	554	−7.8	44
Norfolk, Va.[2] (10 m)	807	13.9	68	759	11.5	59	715	9.0	53	633	3.0	50	559	−4.3	47
Pearl Harbor, T. H.[2] (6 m)	805	14.4	64	758	12.9	47	714	11.0	37	633	6.5	30	560	1.7	25
Pensacola, Fla.[2] (13 m)	807	14.4	78	760	11.4	76	716	8.9	66	633	3.4	62	560	−1.9	60
St. Thomas, V. I.[2] (8 m)	807	13.8	73	760	11.8	60	715	9.0	51	633	2.7	48	560	−2.3	48
Salt Lake City, Utah[1] (1,288 m)	804	20.2	38	758	16.6	41	715	12.9	43	633	5.3	50	560	−2.6	59
San Diego, Calif.[2] (10 m)	805	19.8	35	758	16.5	37	715	12.9	40	634	5.5	43	560	−2.2	48
Seattle, Wash.[2] (10 m)	806	13.2	44	758	10.8	36	714	7.8	33	636	1.5	31	----	----	----
Spokane, Wash.[1] (597)	803	16.5	38	757	12.6	43	713	8.7	47	631	1.9	48	556	−4.5	42
*Washington, D. C.[2] (13 m)	805	12.6	75	756	9.8	71	713	7.0	67	630	1.4	65	556	−4.3	59

Observations taken about 4 a. m. 75th meridian time, except by Navy stations along the Pacific coast and Hawaii where they are taken at dawn.

[1] Weather Bureau. [2] Navy. * Observations by radiometeorograph. Stations not so marked have observations by airplane.

NOTE.—None of the means included in this table are based on less than 15 surface or 5 standard-level observations.

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 5 a. m. (E. S. T.) during July 1938*

[Wind from N=360°, E=90°, etc.]

Altitude (meters) m. s. l.	Albuquerque, N. Mex. (1,554 m)		Atlanta, Ga. (309 m)		Billings, Mont. (1,095 m)		Boston, Mass. (15 m)		Cheyenne, Wyo. (1,873 m)		Chicago, Ill. (192 m)		Cincinnati, Ohio (157 m)		Detroit, Mich. (204 m)		Fargo, N. Dak. (283 m)		Houston, Tex. (21 m)		Key West, Fla. (11 m)		Medford, Oreg. (410 m)		Nashville, Tenn. (194 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	16	0.5	237	0.9	281	1.5	244	1.7	269	2.6	250	0.7	36	0.4	248	1.0	177	0.8	207	0.7	132	2.1	152	0.1	198	1.4
500			235	2.7			277	6.8			241	3.3	263	1.8	252	3.0	121	.7	216	7.7	128	4.4	256	.5	220	4.7
1,000			250	3.6			269	6.6			275	3.8	272	3.7	257	4.7	300	2.9	201	5.3	137	4.3	295	1.2	247	4.6
1,500			263	2.7	167	.8	275	7.5			284	5.2	271	4.1	267	5.5	301	3.6	185	3.5	140	3.3	359	.3	254	3.7
2,000	177	2.1	279	1.8	249	1.1	284	8.4	261	2.8	289	5.9	285	5.2	271	5.6	300	5.5	181	1.8	153	2.2	48	.6	265	3.6
2,500	201	1.5	287	1.2	291	2.8	286	7.5	218	2.8	289	6.1	288	4.6	273	6.3	297	7.0	180	1.0	164	2.0	228	1.9	286	3.5
3,000	278	.5	340	1.2	292	3.9	301	9.0	245	3.4	295	5.7	300	5.5	278	6.8	290	9.5	188	.6	169	1.9	219	3.7	286	3.0
4,000	19	.6	344	2.6	280	6.9	285	12.1	281	3.9	295	5.3	344	4.6	288	9.5	288	10.1	136	.6	252	1.1	241	4.2	294	2.6
5,000	46	.7	23	3.5	285	8.1			275	8.0					301	9.9			83	1.6	248	.7	302	3.8	312	3.4

Altitude (meters) m. s. l.	Newark N. J. (14 m)		Oakland, Calif. (8 m)		Oklahoma City, Okla. (402 m)		Omaha, Nebr. (306 m)		Pearl Harbor, Territory of Hawaii [1] (68 m)		Pensacola, Fla.[1] (24 m)		St. Louis, Mo. (170 m)		Salt Lake City, Utah (1,294 m)		San Diego, Calif. (15 m)		Sault Ste. Marie, Mich. (198 m)		Seattle, Wash. (14 m)		Spokane, Wash. (603 m)		Washington, D. C. (10 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	229	1.3	302	1.9	167	2.4	152	1.0			217	0.8	219	1.0	153	3.6	360	1.9	142	0.3	128	0.4	80	1.7	237	0.5
500	260	4.9	266	3.1	183	4.2	206	2.1			223	2.8	239	3.1			351	1.2	209	1.0	33	3.2			253	4.5
1,000	266	5.6	297	3.3	208	8.1	239	5.3			192	3.1	264	4.2			331	1.3	251	3.5	355	2.6	214	3.1	263	4.8
1,500	260	7.4	238	2.7	219	4.9	256	5.8			186	1.5	279	4.1	153	5.2	271	1.7	256	4.1	336	2.1	236	4.3	265	5.2
2,000	264	8.9	212	3.6	233	3.0	264	6.2			137	1.2	295	4.0	177	2.9			271	4.6	259	1.4	238	4.7	271	5.3
2,500	272	9.0	202	4.3	254	.7	279	5.6			140	1.1	291	3.7	227	2.4			283	5.9	282	3.3	244	4.6	272	5.2
3,000	279	9.4	209	3.8	48	1.0	282	6.0			39	1.2	296	4.4	238	3.0			284	5.9	259	5.3	247	5.1	279	7.2
4,000	285	11.4			116	.3	283	6.0					285	5.0	258	4.6			308	7.8			238	5.6	282	7.7
5,000					245	1.0	304	6.0					290	5.0	261	4.8			304	8.7			271	5.6		

[1] Navy stations.

TABLE 3.—*Maximum free air wind velocities (M. P. S.), for different sections of the United States based on pilot balloon observations during July 1938*

Section	Surface to 2,500 meters (m. s. l.)					Between 2,500 and 5,000 meters (m. s. l.)					Above 5,000 meters (m. s. l.)				
	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station
Northeast [1]	24.7	SW	1,540	23	Boston, Mass	30.8	NW	3,820	2	Burlington, Vt	38.0	WSW	11,500	19	Cleveland, Ohio.
East-Central [2]	27.5	WSW	1,870	1	Cincinnati, Ohio	26.2	NNE	3,810	12	Knoxville, Tenn	40.0	NNW	11,490	4	Richmond, Va.
Southeast [3]	18.8	NE	340	4	Charleston, S. C	19.3	SSW	3,000	29	Charleston, S. C	34.0	N	12,540	6	Charleston, S. C.
North-Central [4]	29.9	NW	1,560	13	Huron, S. Dak	33.6	NW	4,440	13	Huron, S. Dak	46.4	NW	9,830	2	Sault Ste. Marie, Mich.
Central [5]	29.6	W	810	13	Chicago, Ill	27.0	NW	3,700	11	Chicago, Ill	32.0	WNW	10,420	29	Indianapolis, Ind.
South-Central [6]	27.6	SW	1,010	2	Oklahoma City, Okla.	25.6	NNE	4,410	31	Abilene, Tex	35.6	NE	14,260	28	Del Rio, Tex.
Northwest [7]	26.0	WSW	1,710	23	Billings, Mont	27.0	WSW	4,900	30	Boise, Idaho	50.0	NW	9,140	4	Medford, Oreg.
West-Central [8]	21.6	SW	2,280	5	Modena, Utah	36.3	WSW	2,750	11	Rock Springs, Wyo.	42.4	SW	7,520	3	Modena, Utah.
Southwest [9]	20.5	WNW	2,300	18	Havre, Mont	29.1	S	2,660	11	Winslow, Ariz	52.2	SSW	19,780	30	Las Vegas, Nev.

[1] Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and northern Ohio.
[2] Delaware, Maryland, Virginia, West Virginia, southern Ohio, Kentucky, eastern Tennessee, and North Carolina.
[3] South Carolina, Georgia, Florida, and Alabama.
[4] Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.
[5] Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.
[6] Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except El Paso), and western Tennessee.
[7] Montana, Idaho, Washington, and Oregon.
[8] Wyoming, Colorado, Utah, northern Nevada, and northern California.
[9] Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

RIVERS AND FLOODS

[River and Flood Division, MERRILL BERNARD in charge]

By BENNETT SWENSON

During July 1938 precipitation was above normal generally east of the Mississippi River (except over the Great Lakes region), portions of Texas and the Great Basin, and over the middle and extreme upper Missouri Basin. Thus the rainfall was uniformly above normal over large areas during a month which usually has rainfall of a showery type and therefore spotted. Resulting floods, consequently, were more numerous and widespread than usually occur in July.

Atlantic slope and East Gulf drainage.—Heavy rains during most of the last 10 days of July over this entire area caused light to moderate flooding in many of the streams from the James River southward. However, no damages of great consequence were reported.

Missouri Basin.—Normal or slightly higher precipitation during the winter months—December to February—in the upper reaches of the Missouri River watershed, with above-normal precipitation in March in every State except North Dakota, set the stage for at least a normal flow in the river during the snow run-off period, May to July. At the end of March, according to the report in the Climatological Data for Montana, there was about a normal depth of snow in practically all headwater tributary watersheds. The moisture content, however, was high and the ground wet and unfrozen under the snow. In April, the precipitation continued near or above normal, except in North Dakota and Montana, and in May there was an abundance of moisture, being 145 percent of normal in Montana.

The Yellowstone River reached a peak stage of 12.0 feet at Miles City, Mont., on June 26, which is equivalent to approximately 65,000 second-feet when considered in terms of volume discharge. A large portion of the run-off from the upper reaches of the Missouri River was impounded by Fort Peck Dam and a maximum flow of only between 16,000 and 18,000 second-feet was released to pass on down the river.

On July 2 the Missouri River at Williston, N. Dak., reached a stage of 10.9 feet with a flow of about 95,000 second-feet. Prior to this, however, heavy rains in southwestern North Dakota and northwestern South Dakota occurred and the run-off combined with the gradually-rising Missouri River to produce a stage of 12.6 feet at Pierre, S. Dak., on June 30, the flow at this stage being approximately 126,000 second-feet. As this water moved downstream, stages were high in the Big Sioux River and the total flow produced a stage of 12.6 feet at Sioux City, Iowa, on July 3. A number of fairly definite waves proceeded downstream, culminating in gradually higher stages at Omaha and Nebraska City. While the crest of the wave referred to above, 12.6 feet at Pierre, was moving slowly downstream from Sioux City, heavy rains occurred during the period July 2–7 in the area adjacent to the Missouri River between Sioux City and Nebraska City which, when the run-off was added to the water already present, caused increasing stages to the extent that there was considerable overflow in that reach of the river. This overflow resulted in a retardation in the movement of the crest and permitted more or less piling up below Sioux City as the waves continued to come from above that point; so that the combined effect of the numerous flood waves moving downstream and the heavy rains at critical periods produced stages below Sioux City which were the highest since 1927. The crest stage of 18.1 feet at Blair, Nebr., on July 10–11, was the highest July stage of record. At Nebraska City the river rose to bankful stage, 15 feet, during the night of July 3 and remained above until about midday of July 18, with a crest stage of 17.9 feet on July 12. At a stage of 16.5 feet at Nebraska City there is considerable overflow, especially of the east bank, but it is not extremely damaging; above 17.0 feet the overflow becomes serious.

The last wave of any importance to move downstream during this period of high water caused stages of 11.3 feet at Williston, N. Dak., on July 6 and 7, and 14.4 feet at Bismarck N. Dak., on July 8. Both of these stages were the highest reported from these stations during the period of high water and the resulting flow was slightly in excess of 100,000 second-feet. However, as this wave traversed the various reaches of the river, it seemed to flatten out more than the others and when it combined with the slowly moving mass of water below Sioux City it served only to slow up the rate of fall and extend the period of overflow at stations below.

At St. Joseph, Mo., the crest of the high water was reached on July 17 with a stage of 17.0 feet, which is flood stage at that point. The great floods of record in the Missouri River produced stages at St. Joseph as follows: [1]

Year	Stage	Date
	Feet	
1881	27.2	Apr. 29
1903	20.5	June 2
1908	20.4	June 15
1909	18.8	July 11
1910	17.6	Mar. 23
1912	18.4	Apr. 15
1915	17.7	July 21
1927	17.6	May 16
1938	17.0	July 17

On the 16th of July the crest of the high water was practically at Kansas City. The stage on that morning was 18.0 feet and it was expected to round off at 18.1 feet and begin a slow decline. But, during the night of July 16, a torrential downpour occurred in the northeastern portion of the State of Kansas and along the Missouri River in Missouri which caused a very sudden and sustained rise at Kansas City, which is of interest due to the fact that it occurred at that particular and critical time.

This storm was produced by a cold front which was advancing southeastward across Nebraska on July 16, and upon which a warm wave developed. As this frontal system moved southeastward, heavy rains occurred, the heaviest being in the area between Concordia, Kans., and Kansas City, Mo. This seemed to be very much in line with the path traveled by that portion of the frontal system where the warm wave was active.

Examination of the stages which prevailed during this high water and their comparison with the flood stages for the different Missouri River stations would, no doubt,

[1] From St. Joseph, Mo., station annual and Weather Bureau publication "Daily River Stages."

suggest that this was not a serious overflow. Such an examination would reveal the following:

Station	Flood stage	Crest
	Feet	*Feet*
Sioux City	19	12.7
Omaha	19	18.8
Nebraska City	16	17.9
St. Joseph	17	17.0
Kansas City	22	19.2

This, however, does not define the whole nor the true high-water picture and there was a considerable amount of overflow elsewhere than in the vicinity of Nebraska City, although it was here that it was most serious. Many thousand acres of valuable grain, corn, and tobacco land were flooded and the water spread out 3 to 5 miles from its regular channel in some places. With no high water in the Missouri for several years, many farms have extended their cultivation to low ground, and naturally this added to the total of lost acres.

Another interesting sidelight in connection with this high water was the relatively small amount of water which moved downstream when the instantaneous discharge is considered. A discharge measurement made at the peak stage at Nebraska City showed a movement of only 127,000 cubic feet per second, whereas in times past as much as nearly 200,000 second-feet have been recorded with stages much lower. No later than last March, when the wave of water resulting from an ice gorge above Bismarck, N. Dak., was passing downstream, it was determined that at 16.6 feet there was a flow of 125,000 second-feet. A tabulation of the stages with corresponding discharges for the March rise and this one shows clearly the difference in the flow in the Missouri River which is due, not only to the variations in the slope with each wave, but also to the shifting nature of the river bed as well.

Station	March 1938		July 1938	
	Stage	Discharge [1]	Stage	Discharge [1]
	Feet	*Second-feet*	*Feet*	*Second-feet*
Bismarck	20.5	220,000	14.4	110,000
Pierre	12.9	170,000	12.6	126,000
Yankton	9.2	141,000	10.1	116,000
Omaha	18.3	130,000	18.8	125,000
Nebraska City	16.6	125,000	17.9	127,000

[1] From measurements made by the U. S. Geological Survey and rating curves constructed therefrom.

Ohio Basin.—Heavy rainfall over the upper Wabash and West Fork of White Rivers late in June followed by excessive rains over portions of the same area on July 1 and 2 and over the middle and lower portions of the basin on July 2 caused considerable overflow.

The official in charge of the Indianapolis office states that floods of the severity of this June-July overflow are comparatively rare in midsummer. There are no official records of any July stages as high as those of this year in the Wabash Valley. At Mount Carmel, Ill., on the Wabash River, where the records began in 1889, the highest previous July stage (16.3 feet in 1915) is 3.6 feet below that of July 11, 1938, and at Elliston, Ind., on the West Fork of White River, where the stage was 26.1 feet on July 4, 1938, the highest previous July stage since 1908 was 23.1 feet in 1915.

West Gulf of Mexico drainage.—Floods occurred in the Colorado, Nueces, and Rio Grande Rivers near the end of July, but as flood stages continued into August a report will be made later.

Estimated flood losses by drainage basins during July 1938 are as follows:

Atlantic slope drainage:	
Savannah River	$4,500
East Gulf of Mexico drainage:	
Apalachicola River	5,200
Missouri Basin:	
Missouri River	[3] 1,132,635
Ohio Basin:	
Wabash River	934,500
West Fork of White River	909,225
East Fork of White River	145,900
White River	324,000
North Fork of Holston River	15,700
Columbia Basin:	
Deer Lodge County, Mont	250,000
Total	3,721,660

[3] $39,000 occurred in Montana; 3 lives lost.

Table of flood stages during July 1938

[All dates in July unless otherwise specified]

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC SLOPE DRAINAGE					
James:	*Feet*			*Feet*	
Columbia, Va	10	23	26	19.0	24
Richmond, Va	8	25	25	8.1	25
Roanoke:					
Randolph, Va	21	23	26	23.4	25
Weldon, N. C	31	23	30	44.1	28
Williamston, N. C	10	(1)	9		
		26	(2)	13.7	31
Tar:					
Rocky Mount, N. C	8	26	(2)	11.0	30
Tarboro, N. C	18	30	(2)	20.2	Aug. 1
Greenville, N. C	13	28	(2)	15.0	Aug. 2
Little: Kenly, N. C	8	26	28	9.2	27
Neuse:					
Neuse, N. C	14	24	(2)	22.0	29
Smithfield, N. C	13	25	(2)	19.5	31
Goldsboro, N. C	14	(1)	5	17.2	1
		27	Aug. 8	19.2	Aug. 4
Kinston, N. C	14	(1)	7	15.2	4
Haw: Moncure, N. C	20	25	27	[3] 25.0	26
Cape Fear:					
Fayetteville, N. C	35	26	28	42.4	27
Lock No. 2, Elizabethtown, N. C	20	25	31	30.7	28
Peedee:					
Cheraw, S. C	30	25	27	33.7	26
Mars Bluff Bridge, S. C	17	26	Aug. 3	20.3	31
Poston, S. C	18	31	Aug. 6	19.6	Aug. 3
Saluda:					
Pelzer, S. C	6	22	24	8.0	23
Chappells, S. C	15	25	27	16.9	27
Broad: Blairs, S. C	14	24	26	17.5	26
Santee:					
Rimini, S. C	12	25	(2)	14.4	31
Ferguson, S. C	12	28	(2)	13.4	Aug. 1
Broad: Carlton, Ga	15	25	25	15.9	25
Savannah:					
Butler Creek, Ga	21	24	28	23.4	26-27
Clyo, Ga	11	30	(2)	(4)	
Oconee: Milledgeville, Ga	20	26	28	22.5	27
Altamaha: Charlotte, Ga	12	28	(2)	12.5	31
EAST GULF OF MEXICO DRAINAGE					
Apalachicola: Blountstown, Fla	15	27	Aug. 1	18.0	29
Choctawhatchee: Caryville, Fla	12	31	31	12.1	31
Oostanaula: Resaca, Ga	22	24	27	23.2	26
Cahaba: Centerville, Ala	23	25	25	[3] 24.5	25
MISSISSIPPI SYSTEM					
Upper Mississippi Basin					
Rock: Moline, Ill	10	3	9	10.6	6
Illinois:					
Peru, Ill	17	6	6	17.0	6
Havana, Ill	14	8	16	14.4	10-11
Beardstown, Ill	14	9	13	14.2	10-11

[1] Continued from June.
[2] Continued into August.
[3] Estimated.
[4] Crest occurred in June.

Table of flood stages during July 1938—Continued

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
MISSISSIPPI SYSTEM—continued					
Missouri Basin					
	Feet			*Feet*	
Big Blue: Blue Rapids, Kans	20	17	17	21.0	17
Missouri:					
Blair, Nebr	18	10	11	18.1	10–11
Nebraska City, Nebr	15	3	18	17.9	12
St. Joseph, Mo	17	17	17	17.0	17
Ohio Basin					
Little Miami: Kings Mills, Ohio	17	14	14	20.9	14
West Fork of White:					
Elliston, Ind	18	2	8	26.1	6
Edwardsport, Ind	12	(1)	10	18.9	8
East Fork of White: Seymour, Ind	14	5	6	15.0	6
White:					
Petersburg, Ind	16	9	11	17.4	10
Hazleton, Ind	16	9	12	18.0	11
Wabash:					
Wabash, Ind	12	1	2	13.7	2
La Fayette, Ind	11	(1)	5	17.0	3
Covington, Ind	16	(1)	7	22.2	3
Terre Haute, Ind	14	(1)	9	20.9	4
Vincennes, Ind	14	5	12	18.7	9
Mt. Carmel, Ill	19	9	12	19.9	11
New Harmony, Ind	15	11	13	15.7	13
Big Pigeon: Newport, Tenn	6	24	24	7.0	24
French Broad: Oldtown (near Newport), Tenn	6	23	24	9.2	24
MISSISSIPPI SYSTEM—continued					
Ohio Basin—Continued					
Tennessee:	*Feet*			*Feet*	
Widows Bar Lock, Ala.: Upper gage	17	26	26	17.1	26
Florence, Ala	18	28	29	18.4	29
WEST GULF OF MEXICO DRAINAGE					
Colorado:					
Marble Falls, Tex	21	22	28	36.4	25
Austin, Tex	21	23	27	33.0	25
Nueces: Cotulla, Tex	15	30	Aug. 1	17.0	31
Rio Grande:					
Del Rio, Tex	15	23	26	20.2	24
Eagle Pass, Tex	16	23	27	24.2	24
Rio Grande City, Tex	21	26	29	24.9	28
Hidalgo, Tex	21	28	31	22.2	30
Mercedes, Tex	21	28	Aug. 1	21.9	31
Brownsville, Tex	18	Aug. 1	Aug. 2	18.1	Aug. 2
PACIFIC SLOPE DRAINAGE					
Columbia Basin					
Columbia: Vancouver, Wash	15	(1)	8	(4)	-------

[1] Continued from June.
[4] Crest occurred in June.

WEATHER ON THE ATLANTIC AND PACIFIC OCEANS

[The Marine Division, I. R. TANNEHILL in charge]

NORTH ATLANTIC OCEAN, JULY 1938

By H. C. HUNTER

Atmospheric pressure.—Most of the North Atlantic area had pressure greater than normal, though the departures were small. A slight deficiency appeared in the far southwestern part, and a more marked one extended from the vicinity of the British Isles northwestward to Greenland; in this latter area the station at Reykjavik, Iceland, reported a mean pressure 0.15 inch less than normal. During most of the first half of July the Azores HIGH was displaced somewhat to eastward of its average position, but during the second half, to westward, toward Bermuda.

The extremes of pressure in trustworthy available vessel reports were 30.66 and 29.29 inches. The higher reading was noted more than 200 miles to north-northwestward of Horta during the forenoon of the 4th by the British steamship *Tucurinca*. The Dutch liner *Statendam* recorded the lower reading when 100 miles south of the southernmost point of Ireland, about noon of the 7th.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, July 1938*

Station	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland	29.77	−0.03	30.12	3	29.40	26
Reykjavik, Iceland	29.69	−.15	30.06	7	29.21	23
Lerwick, Shetland Islands	29.79	−.01	30.15	16	29.47	30
Valencia, Ireland	29.94	−.04	30.24	16, 18	29.59	30
Lisbon, Portugal	30.12	+.10	30.33	3	29.92	14
Madeira	30.12	+.07	30.39	7	29.97	20
Horta, Azores	30.33	+.06	30.64	3	29.94	30
Belle Isle, Newfoundland	29.96	+.07	30.32	2	29.58	16
Halifax, Nova Scotia	30.02	+.07	30.26	23–25	29.72	4
Nantucket	30.00	+.02	30.21	22	29.75	2
Hatteras	30.06	+.05	30.21	22	29.81	3
Bermuda	30.21	+.03	30.34	29	29.94	4
Turks Island	30.04	−.03	30.19	9	29.92	5
Key West	30.02	−.01	30.14	9	29.89	5
New Orleans	29.99	−.01	30.17	10	29.81	5

NOTE.—All data based on a. m. observations only, with departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

Cyclones and gales.—Three storm areas of moderate importance affected the northeastern part of the North Atlantic during the first half of July. Otherwise the month had no features of special importance.

On the 3d a LOW was centered nearly over the south coast of Iceland, whence it traveled at first southeastward, so that by the morning of the 5th it was over Great Britain as a well-developed storm. Thereafter it moved northeastward and reached southern Norway late on the 6th. Several vessels encountered fresh to strong gales, mostly within the southwest quadrant of this LOW. The American liner *Washington*, New York to Cobh, met strong winds on the 4th, the day before arrival at Cobh, and press reports state a few passengers suffered minor injuries.

In the southwestward extension of the LOW just mentioned there was a marked new development by the 6th, and a well-formed storm appeared some distance to the southwestward of Ireland. This storm advanced toward the east-northeast, so that the center was near Lands End early on the 7th, with considerable intensity. Thereafter its course was almost northward and the morning of the 9th found it centered over the northern part of the North Sea, with slightly less energy. Several vessels met fresh gales connected with this storm, and the American steamship *Nemaha* encountered a whole gale on the 6th, near 42° N., 18° W.

The third storm center of moment was located to southeastward of Cape Farewell on the morning of the 12th. It moved to the eastward, approximately on the 60th parallel, and gained in strength for a time. Late on the 13th it turned more toward the north over waters east of Iceland, and on the 15th was centered near Jan Mayen Island, where there are very few reporting vessels. However, on the 13th the American liner *Scanpenn*, near 56° N., 26° W., reported force 10 (whole gale), the second and final instance of such force this month over Atlantic waters.

During the last 2 days of the month squally weather was encountered in the Caribbean Sea, not far to south-

ward of the Yucatan Channel; however, no definite cyclonic development was indicated.

Fog.—July was foggier than normal over most northern portions of the North Atlantic. As a rule there was more fog than during the preceding month, and this was notably the case to northward of the 45th parallel between the 20th and 40th meridians. A decrease in fogginess from June to July is indicated for the area just to eastward of Chesapeake and Delaware Bays and also for the section a short distance to northwestward of the westernmost Azores.

The square of most frequent fog was in the Cape Cod-Maine-Nova Scotia region, where 23 days gave reports of fog. Next was a square at the southern tip of the Grand Banks, 40° to 45° N., 45° to 50° W., with 22 days. In that part of the Atlantic to eastward of the 40th meridian the foggiest square (45° to 50° N. and 25° to 30° W.) had 11 days. It was noteworthy that between the 40th meridian and Europe fog was seldom met after the 18th.

OCEAN GALES AND STORMS, JULY 1938

Vessel	Voyage		Position at time of lowest barometer		Gale began July—	Time of lowest barometer July—	Gale ended July—	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				*Inches*					
Caledonia, Br. S. S.	Glasgow	New York	55 13 N.	19 03 W.	3	Mdt, 3	4	29.60	W	W, 7	NW	NW, 8	W-WNW.
Black Hawk, Am. S. S	Rotterdam	do	49 49 N.	12 16 W.	4	3p, 4	5	29.86	WNW	WNW, 6	WNW	WNW, 9	W-WNW.
Bilderdijk, Du. S. S.	do	do	49 41 N.	9 56 W.	4	8p, 4	5	29.77	W	W, 7	WNW	WNW, 8	W-WNW.
Hermes, Du. S. S.	Amsterdam	San Juan	43 43 N.	20 04 W.	5	2a, 6	6	29.77	WSW	WNW	NNW	NW, 8	WNW-NW.
Nemaha, Am. S. S.	Rotterdam	New Orleans	42 20 N.	18 00 W.	6	6a, 6	6	29.90	NW	NW, 10	NW	NW, 10	None.
City of Omaha, Am. S. S.	London	Tampico	45 06 N.	15 30 W.	6	11a, 6	6	29.65	NNW	WSW, 4	NNW	NNW, 8	SW-W.
Camito, Br. S. S.	Avonmouth	Jamaica	46 18 N.	16 18 W.	6	11a, 6	6	29.64	N	W, 4	N	N, 8	SSW-NNW.
Marguerite Finaly, Fr. M. S.	Hamburg	Aruba	48 30 N.	9 42 W.	7	2a, 7	8	29.52	N	N, 8	WNW	NNW, 8	N-NW.
Statendam, Du. S. S.	Rotterdam	New York	50 05 N.	8 58 W.	7	Noon, 7	8	29.29	S	NNW, 9	NW	NNW, 9	S-NNW.
American Shipper, Am. S. S.	Belfast	Boston	54 55 N.	17 00 W.	10	8p, 10	11	29.72	W	W, 8	W	W, 8	None.
Scanpenn, Am. S. S.	Copenhagen	Wilmington	56 02 N.	26 30 W.	12	6a, 13	14	29.39	WSW	W, 9	NW	WNW, 10	WSW-WNW.
Svanhild, Dan. S. S.	Aalborg	New York	58 30 N.	15 30 W.	13	11p, 13	14	[1] 29.17	S	SW, 7	WNW	WNW, 8	S-WNW.
Castilla, Hond. S. S.	Philadelphia	Barrios	20 06 N.	86 00 W.	31	6a, 31	31	29.94		E, 4		SE, 6	SE-E.
Cefalu, Hond. S. S.	Havana	Cristobal	20 12 N.	84 06 W.	30	7a, 31	31	29.97		ESE, 5		SE, 6	
NORTH PACIFIC OCEAN													
Hikawa Maru, Jap. M. S.	Vancouver, B. C.	Yokohama	43 50 N.	152 10 E.	1	10a, 1	1	29.21	SW	SW, 8	W	WSW, 8	SE-SW-WNW.
President Jefferson, Am. S. S.	Seattle	do	47 15 N.	163 45 E.	1	4a, 2	2	29.61	SE	SSE, 9	SSE	SSE, 9	SE-S.
Hoegh Hood, Nor. M. S.	Estero Bay	Kobe	35 00 N.	158 12 E.	8		8		S		S	S, 8	
Northland, U. S. C. G.			65 42 N.	169 00 W.	9	1p, 10	10	29.67	N	N, 5	N	N, 8	None.
Columbian, Am. S. S.	Los Angeles	Balboa	13 06 N.	93 18 W.	18	5p, 17	18	29.83	NE	SW, 1	NE	NE, 10	
Kaijo Maru, Jap. M. S.	do	Yokohama	37 42 N.	144 30 E.	25	5a, 25	25	29.72	ESE	SE, 8	SE	SE, 8	ESE-SE.
San Marcos, Am. S. S.	San Diego	Balboa	13 03 N.	93 17 W.	28	2a, 28	28	29.90	E	E, 2	E	E, 9	

[1] Barometer uncorrected.

NORTH PACIFIC OCEAN, JULY 1938

By WILLIS E. HURD

Atmospheric pressure.—Stable anticyclonic pressure conditions existed over middle latitudes on the eastern two-thirds of the North Pacific Ocean during the greater part of July 1938. Even in higher latitudes, extending well into the Bering Sea, the average barometer was unusually high, as may be observed in the accompanying table, and the Aleutian LOW, for the first time since August 1937, had become practically nonexistent.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, July 1938, at selected stations*

Station	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Point Barrow	29.80	−0.12	30.04	28	29.56	10
Dutch Harbor	29.99	+.05	30.34	30, 31	29.56	7
St. Paul	29.97	+.13	30.26	22	29.44	9
Kodiak	30.00	+.06	30.34	22	29.42	11
Juneau	30.07	+.02	30.45	23	29.72	9
Tatoosh Island	30.09	+.04	30.29	18	29.79	25
San Francisco	29.97	+.02	30.14	4	29.81	23
Mazatlan	29.90	+.04	29.98	1	29.78	7
Honolulu	30.02	.00	30.11	19	29.94	31
Midway Island	30.14	+.03	30.27	11	30.00	1
Guam	29.81	−.03	29.94	3	29.71	14, 15
Manila	29.78	+.04	29.89	7	29.71	4, 27
Hong Kong	29.70	+.05	29.82	7	29.52	4
Naha	29.79	+.07	30.00	6	29.53	30
Titijima	29.85	.00	30.09	4	29.56	13
Petropavlosk	29.88		30.18	11	29.53	21

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

While low pressure conditions prevailed over western Mexico and the adjoining west coast, and in the Far East, average pressures in these regions, except at Guam, were normal to slightly above.

Extratropical cyclones and gales.—While several low pressure areas crossed northern waters of the North Pacific during July 1938, none was very active, and no gales were reported for the entire region east of the 170th meridian of east longitude, except in the Tropics and in Bering Strait.

In middle and higher east longitudes gales were few in number and occurred within the region 35° to 48° N., 144° to 165° E. These gales, of force 8 to 9, were experienced on the 1st, 2d, 8th, and 25th. That of the 1st, of force 8, barometer 29.21, to the immediate southward of the Kuril Islands, was in connection with the deepest cyclone of record during the month.

Tropical cyclones and gales.—On the 18th and 28th of July strong to whole gales were reported south of the Gulf of Tehuantepec, both near 13° N., 93° W. The former, of force 10 from the northeast, lowest barometer 29.83, was encountered by the American steamer *Columbian;* the latter, of force 9 from the east, barometer 29.90, was experienced during the early morning by the American steamer *San Marcos*. The gale of the 18th appeared to be due only to locally squally conditions; that of the 28th, to a probable cyclonic disturbance, central, according to the Mexican Meteorological Service, to the southward.

Several tropical LOWS appeared in the Far East, but we have no present information that they were severe.

The French motorship *Jean Laborde*, in the China Sea on July 7, reported the existence of a typhoon about 150 miles east of Tourane moving northwestward. Our weather maps show the presence of a rather deep LOW in the same vicinity on the 23d. The British motorship *Taybank*, east of the central Philippines on the 16th to 18th, reported a typhoon in the vicinity.

Fog.—There were some 6 to 8 or more days with fog along most parts of the northern sailing routes to the westward of about 150° west longitude extending almost to the Japanese coast. The Norwegian motorship *Ringwood*, Yokohama toward Portland, Oreg., July 4–14, reported "dense fog and fog patches, sometimes wet and sometimes dry, during the whole voyage," with "intervals between the patches not exceeding 4–5 hours." No fog was reported off the Washington and Oregon coasts, but it was observed on the 11th, 12th, and 31st between Point Conception and San Pedro, and on the 14th and 17th off Lower California. In the Bering Sea, between St. Paul and Dutch Harbor, 9 days, from the 6th to 18th, were reported with fog.

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

TABLE 1.—*Condensed climatological summary of temperature and precipitation by sections, July 1938*

[For description of tables and charts, see REVIEW, January, p. 29]

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	80.4	+0.1	4 stations	101	[1]4	5 stations	60	1	7.54	+2.18	Citronelle	13.37	Wheeler Dam	3.14
Arizona	79.2	−.9	Quartzsite	119	31	Bright Angel R. S.	31	5	1.54	−.71	Bisbee	6.37	3 stations	T
Arkansas	82.0	+1.5	Hot Springs	109	13	2 stations	59	[1]4	3.74	−.06	Corning	12.90	Arkansas City	.65
California	73.0	−.6	Cow Creek	125	21	Ellery Lake	26	4	.15	+.08	Twin Lakes	2.50	119 stations	.00
Colorado	67.2	+.1	2 stations	108	[1]9	Dillon	22	7	1.67	−.53	San Isabel	8.93	Fruita	T
Florida	80.2	−1.1	Niceville	100	3	3 stations	60	[1]1	8.49	+1.25	Sarasota	18.78	Fernandina	2.30
Georgia	78.8	−1.3	2 stations	102	[1]9	Blairsville	47	1	7.57	+1.80	Blairsville	14.91	Warrenton	2.89
Idaho	68.2	+.1	Lewiston	113	[1]22	Pelton Ranch	28	4	1.14	+.47	Hailey	2.98	Kellogg	.08
Illinois	77.1	+.6	Greenville	103	11	Dixon	50	21	4.74	+1.46	Mt. Carmel	12.12	Mt. Vernon	1.63
Indiana	75.6	−.1	Elliston	105	11	Salamonia	50	5	5.25	+1.89	La Porte	10.84	Anderson	2.06
Iowa	76.5	+1.9	Omaha	107	11	Sibley	48	23	4.24	+.57	Sac City	12.02	Tingley	.52
Kansas	80.9	+1.8	2 stations	110	[1]2	Garden City	50	23	2.90	−.29	Atchison	7.56	Minneola	.50
Kentucky	77.2	.0	do	100	[1]10	Danville	52	2	7.27	+3.10	Quicksand	15.43	Monticello	3.01
Louisiana	81.9	+.1	Calhoun	105	5	Franklinton	60	1	6.17	+.03	Delta Farms	14.49	Natchitoches	1.00
Maryland-Delaware	75.9	+.6	Cumberland, Md.	99	8	2 stations	42	5	7.33	+3.11	Crisfield, Md.	15.04	Woodstock, Md.	3.75
Michigan	69.4	+.3	2 stations	94	7	Dukes	31	21	2.66	−.24	Coldwater	6.94	Mackinac Island	.56
Minnesota	70.3	+.3	do	100	12	2 stations	38	26	3.30	+.01	Rochester	9.66	Pigeon River Bridge	1.11
Mississippi	82.0	+.9	do	103	[1]4	Shubuta	60	5	5.39	+.36	Pearlington	12.29	Batesville	1.41
Missouri	79.7	+1.7	Unionville	110	12	4 stations	53	[1]15	3.50	−.19	New Madrid	9.49	Galena	.37
Montana	67.3	+.4	Libby	104	22	Summit	32	[1]26	2.09	+.61	Lustre (near)	4.96	Heron	.02
Nebraska	77.2	+1.8	Benkelman	111	[1]10	Mullen	45	[1]8	3.23	+.08	Madison	8.47	Lyman	.44
Nevada	72.5	.0	Las Vegas Airport	115	31	Sheldon	33	5	.76	+.37	Gerlach	2.37	3 stations	T
New England	69.7	+.6	Falls Village, Conn.	95	7	Somerset, Vt.	38	[1]7	7.75	+3.99	Milford, Mass.	14.52	Nantucket, Mass.	2.00
New Jersey	74.7	+1.0	Bridgeton	98	10	2 stations	43	[1]3	8.84	+4.05	Long Branch	16.17	Little Falls	6.29
New Mexico	70.7	−1.5	Orogrande	104	[1]7	Elizabethtown	27	6	2.31	−.21	Cloudcroft	8.06	Shiprock	.00
New York	70.8	+1.1	2 stations	96	[1]8	Indian Lake	35	3	5.11	+1.19	Boyds Corners	12.22	Utica	1.79
North Carolina	75.7	−1.2	do	99	[1]11	Mt. Mitchell	41	1	7.75	+1.87	Rock House	17.89	Hatteras	1.90
North Dakota	69.7	+.9	McClusky	104	31	2 stations	39	25	3.34	+.90	Maddock	6.73	Timmer	.91
Ohio	74.2	+.5	Gallipolis (near)	99	8	3 stations	48	[1]3	4.99	+1.17	Portsmouth No. 2	11.76	Norwalk	1.50
Oklahoma	82.3	+.5	Hollis	109	13	2 stations	54	10	2.63	−.23	Hugo	8.21	Oakwood	.40
Oregon	68.1	+1.6	Umatilla	112	21	Chemult	23	5	.51	+.10	Enterprise	2.02	4 stations	T
Pennsylvania	73.2	+1.0	Marcus Hook	100	10	Coudersport	40	[1]5	4.81	+.52	Ardmore	11.26	Lock No 2	.97
South Carolina	78.4	−1.6	Lake City	101	10	Long Creek (near)	50	1	6.90	+1.06	Long Creek (near)	13.18	Little Mountain	2.78
South Dakota	74.6	+1.6	Pukwana	108	12	2 stations	45	[1]8	2.04	−.41	Vermillion	5.63	Faulkton	.63
Tennessee	78.2	+.5	2 stations	101	[1]6	Gatlinburg	52	1	6.37	+1.88	Waynesboro	14.19	Covington	.50
Texas	82.9	−.1	do	110	[1]6	2 stations	52	[1]8	3.43	+.80	Sloan	22.58	6 stations	.00
Utah	70.0	−1.7	do	107	31	do	28	[1]6	.67	−.26	Park Valley	2.51	2 stations	.00
Virginia	75.4	.0	Lincoln	101	10	Big Meadows	48	4	7.20	+2.65	Christchurch	15.09	Mount Weather	1.96
Washington	69.2	+2.9	Hanford	114	22	2 stations	32	[1]4	.36	−.34	Mt. Baker Lodge	1.58	6 stations	.00
West Virginia	73.6	+.4	Inwood	103	11	Bayard	37	5	5.58	+.99	Rowlesburg	11.50	Dam 13, O. R.	1.16
Wisconsin	70.1	.0	Eau Claire	95	12	Laona	35	15	4.41	+.87	Deerskin Dam	10.14	Plum Island	.87
Wyoming	65.0	−.6	Casper	105	11	Fox Park	28	8	1.70	+.35	Spencer (near)	4.52	Elk Mountain	.13
Alaska (June)	51.3	−1.1	Richardson	95	27	Barrow	18	10	2.52	+.82	Cordova	17.03	Kotzebue	T
Hawaii	74.9	+.8	3 stations	92	[1]15	Kanalohuluhulu	47	4	4.71	−1.12	Hilo-Manawaiopuna Divide.	19.50	6 stations	.00
Puerto Rico	78.0	−.3	Juncos	97	6	Garzas	56	7	4.55	−1.62	La Mina(El Yunque)	11.91	Ensenada	.81

[1] Other dates also.

TABLE 2.—*Climatological data for Weather Bureau stations, July 1938*

[Compiled by Annie E. Small, by official authority U. S. Weather Bureau]

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Days with 0.01 inch or more	Wind: Average hourly velocity	Prevailing direction	Maximum velocity: Miles per hour	Maximum velocity: Direction	Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Mi.								0–10	In.	In.
New England							**69.7**	**+0.8**										**84**	**6.18**	**+2.7**										**6.5**		
Eastport	75	67	85	29.88	29.96	+0.03	59.4	−1.0	85	31	66	48	3	52	25	57	56	94	4.70	+1.6	19	8.3	s.	24	sw.	24	4	7	20	7.5	0.0	0.0
Greenville, Maine	1,069	4	41																													
Portland, Maine	103	82	117	29.83	29.95	.00	68.3	+.2	90	31	76	54	3	61	28	63	60	82	5.67	+2.4	18	7.7	sw.	25	s.	1	10	9	12	5.9	.0	.0
Concord	289	54	72	29.65	29.96	.00	71.1	+2.6	90	27	80	49	7	62	33				7.57	+4.0	14	5.1	s.	19	s.	29	10	11	10	5.6	.0	.0
Burlington	403	11	48	29.50	29.92	−.02	69.8	−.5	87	31	78	51	3	62	28	64	62	78	4.69	+1.2	17	8.3	s.	23	s.	14	4	9	18	7.0	.0	.0
Northfield	876	12	60	29.02	29.95	+.01	66.8	+.9	87	31	77	43	7	56	36	63	60	81	5.59	+2.0	19	6.8	s.	20	n.	4	4	12	15	7.1	.0	.0
Boston [1]	29	33	62	29.93	29.96	.00	71.8	+.1	90	31	79	54	4	64	27	66	63	79	9.46	+6.0	17	9.3	sw.	31	sw.	23	3	12	16	7.3	.0	.0
Nantucket	12	14	90	29.99	30.00	+.02	69.4	+1.6	81	11	75	55	1	64	18	66	65	92	2.00	−.9	13	13.2	s.	28	s.	15	7	8	16	6.6	.0	.0
Block Island	26	11	46	29.96	29.99	+.02	69.6	+1.2	80	31	75	56	4	64	18	67	66	91	3.08	.0	13	12.3	s.	24	sw.	15	10	11	10	5.3	.0	.0
Providence	159	215	251	29.81	29.98	+.01	73.2	−.2	90	10	81	53	4	65	28	67	64	78	6.92	+3.6	15	9.6	s.	27	nw.	11	6	14	11	6.5	.0	.0
Hartford	159	66	100	29.79	29.96	−.01	73.5	+1.9	90	10	82	54	4	65	30				11.24	+6.9	14	7.7	s.	25	sw.	9	4	12	15	6.6	.0	.0
New Haven	106	74	153	29.87	29.98	+.01	73.5	+1.7	90	10	80	56	4	66	28	68	66	79	7.05	+2.7	15	7.9	s.	24	sw.	23	7	11	13	6.3	.0	.0
Middle Atlantic States							**75.7**	**+0.8**										**77**	**6.10**	**+1.7**										**6.5**		
Albany [1]	292	26	37	29.63	29.94	−.02	72.8	+.2	92	31	83	49	3	63	35	66	63	75	5.11	+1.7	17	7.7	s.	36	nw.	29	4	9	18	6.8	.0	.0
Binghamton	871	57	79	29.06	29.97	.00	72.5	+2.5	93	8	84	46	7	62	40	65	62	74	2.79	−.9	12	5.4	sw.	18	w.	26	0	12	19	8.1	.0	.0
New York	314	415	454	29.64	29.97	−.01	75.1	+1.3	90	29	82	57	4	68	20	68	64	76	6.41	+2.2	16	11.6	s.	43	w.	29	6	10	15	6.7	.0	.0
Harrisburg	374	94	104	29.57	29.96	−.02	75.7	+.9	93	10	85	57	5	67	28	68	64	71	2.65	−1.2	15	6.1	w.	27	w.	29	6	14	11	6.0	.0	.0
Philadelphia	114	174	367	29.87	29.99	+.01	77.2	+1.0	94	10	85	61	4	69	24	69	66	72	6.52	+2.4	16	11.2	sw.	37	nw.	11	6	13	12	6.2	.0	.0
Reading	323	283	306	29.63	29.97		75.4	−.1	92	11	84	56	4	66	28	68	64	73	7.78	+3.5	14	8.6	s.	33	nw.	11	7	12	12	6.0	.0	.0
Scranton	805	72	104	29.12	29.97	−.01	73.3	+1.6	92	8	84	50	3	63	38	66	62	72	4.97	+.9	11	5.5	sw.	19	nw.	4	6	16	9	5.9	.0	.0
Atlantic City	52	37	172	29.94	29.99	+.01	73.0	+.9	86	12	78	60	4	68	22	69	68	86	7.08	+3.2	15	14.0	s.	38	sw.	14	5	14	12	6.3	.0	.0
Sandy Hook	22	10	55	29.95	29.97		75.3	+1.8	91	10	81	60	4	69	21	69	67	81	7.27	+2.2	16	10.6	s.	41	w.	20	6	12	13	6.3	.0	.0
Trenton	190	89	107	29.77	29.97		76.0	+1.5	93	10	85	56	4	67	29	69	66	75	8.43	+4.5	16	7.5	s.	30	nw.	29	2	14	15	7.2	.0	.0
Baltimore	123	100	215	29.85	29.98	.00	79.1	+1.9	97	10	88	62	4	70	27	70	66	72	4.87	+.2	18	9.0	sw.	39	se.	12	5	13	13	6.4	.0	.0
Washington	112	62	85	29.86	29.98	.00	78.4	+1.6	96	10	88	60	5	69	27	70	67	75	5.06	+.4	17	5.0	sw.	27	w.	29	6	11	14	6.3	.0	.0
Cape Henry	18	8	54	30.00	30.02		77.6	+.1	94	18	85	59	4	70	22	72	71	84	5.97	+.6	10	9.2	sw.	27	se.	12	6	14	11	6.3	.0	.0
Lynchburg	686	144	184	29.29	30.02	+.01	77.3	−.2	95	11	87	60	1	68	27	69	67	78	5.73	+1.5	16	6.0	sw.	26	sw.	30	7	12	12	6.5	.0	.0
Norfolk	91	80	125	29.93	30.02	+.02	79.0	+.3	95	18	87	63	5	71	24	71	68	76	5.28	−.5	12	9.0	sw.	29	se.	28	3	8	20	7.7	.0	.0
Richmond	144	11	52	29.87	30.01	.00	77.1	−1.4	93	18	86	59	5	68	24	71	68	82	9.71	+5.0	15	7.1	sw.	31	nw.	11	11	10	10	5.3	.0	.0
Wytheville	2,304	49	55	27.68	30.03	+.02	71.6	−1.0	88	28	80	56	1	63	28	66	64	82	8.02	+4.0	16	4.8	w.	16	sw.	31	7	11	13	6.7	.0	.0
South Atlantic States							**78.4**	**−0.7**										**79**	**6.04**	**+0.2**										**6.1**		
Asheville	2,253	89	104	27.74	30.02	.00	73.8	+2.1	92	11	84	54	1	64	31	67	65	81	4.90	+.6	13	6.3	se.	24	nw.	14	4	10	17	6.8	.0	.0
Charlotte	779	63	86	29.21	30.02	.00	78.2	−.2	95	17	87	60	1	70	28	70	67	76	4.82	−.3	14	6.6	s.	24	nw.	14	4	12	15	6.8	.0	.0
Greensboro [1]	886	5	56	29.11	30.05		76.1		92	13	85	55	1	67	27	70	68	83	6.53		18	6.8	s.	32	nw.	14	5	8	18	7.1	.0	.0
Hatteras	11	6	50	30.05	30.06	+.05	78.0	−.2	86	22	83	66	5	73	15	74	72	84	1.90	−3.6	10	11.7	sw.	26	sw.	12	12	13	6	5.0	.0	.0
Raleigh	376	103	140	29.62	30.01	−.01	77.6	−1.2	94	17	86	60	4	69	24	71	68	79	5.01	−.4	13	7.7	sw.	26	w.	18	8	11	12	5.7	.0	.0
Wilmington	72	73	107	29.97	30.04	+.03	78.2	−.9	91	27	85	63	6	72	22	73	71	81	11.00	+3.9	16	9.5	sw.	27	s.	14	10	8	13	5.4	.0	.0
Charleston	48	11	92	30.00	30.05	+.02	80.0	−1.4	93	3	86	68	6	74	17	74	72	78	5.99	−.9	13	9.5	s.	26	ne.	4	6	9	16	6.8	.0	.0
Columbia, S. C.	347	70	91	29.67	30.04	+.02	79.3	−1.6	93	16	88	62	1	70	24	71	68	75	7.91	+2.6	11	7.6	s.	24	s.	21	10	12	9	5.2	.0	.0
Greenville, S. C.	1,039	139		28.94	30.01		77.2	+.3	93	2	86	60	1	68	26	70	67	75	4.26	−1.1	13	6.1	s.	28	n.	14	3	14	14	6.8	.0	.0
Augusta	182	62	77	29.82	30.01	−.01	79.8	−1.5	97	16	89	64	1	71	26	72	69	78	6.31	+.9	14	5.2	s.	19	sw.	19	8	11	12	5.9	.0	.0
Savannah	65	73	152	29.96	30.04	+.01	80.4	−1.1	93	27	88	67	6	72	23	73	71	80	3.84	−2.8	16	9.1	sw.	32	nw.	19	7	10	14	6.1	.0	.0
Jacksonville	43	86	110	30.00	30.05	+.02	80.0	−2.1	93	3	88	66	6	72	23	73	71	81	9.99	+3.3	14	7.3	s.	28	s.	29	7	13	11	6.1	.0	.0
Florida Peninsula							**81.3**	**−0.4**										**78**	**6.92**	**+0.8**										**4.6**		
Key West	21	10	64	30.00	30.02	−.01	83.4	−.1	92	1	89	72	2	78	18	76	73	74	3.25	.0	9	8.8	e.	24	w.	4	6	16	9	6.0	.0	.0
Miami	25	124	168	30.02	30.05	+.01	81.0	.0	92	4	87	70	6	76	18	75	73	76	6.15	+.7	21	7.9	se.	27	s.	22	7	14	10	6.2	.0	.0
Tampa	35	88	197	30.01	30.04	.00	80.9	−.3	92	18	89	70	30	73	20	73	72	83	10.11	+2.2	20	8.8	se.	41	se.	31	3	21	7	6.0	.0	.0
Titusville	43	5	36				79.8	−1.4	92	3	89	67	1	70	24	75	73		7.85	+.5	20		se.				2	14	15		.0	.0
East Gulf States							**80.5**	**0.0**										**79**	**7.70**	**+2.0**										**6.7**		
Atlanta [1]	976	5	53	29.00	30.00	−.02	79.2	+1.1	98	14	89	59	1	70	29	71	68	76	3.88	−.8	10	6.5	s.	29	se.	10	3	14	14	6.9	.0	.0
Macon	370	79	87	29.63	30.02	.00	79.6	−1.6	95	13	89	62	1	70	26	72	70	79	8.48	+3.7	14	5.7	s.	23	s.	18	4	12	15	7.0	.0	.0
Thomasville	273	49	58	29.74	30.03	.00	79.8	+2.0	96	9	89	66	6	70	26	73	71		5.44	−1.3	18		sw.				6	11	14	6.2	.0	.0
Apalachicola	35	11		29.98	30.02		80.4	−1.3	93	4	86	70	1	75	15	75	73	79	7.20	−.5	18	6.9	s.	22	se.	31	6	9	16	6.8	.0	.0
Pensacola	56	149	185	29.95	30.01	.00	79.6	−1.4	96	4	84	71	22	75	17	75	73	82	10.85	+4.1	16	10.6	s.	34	s.	30	9	11	11	5.9	.0	.0
Anniston	741	9					78.8	−.1	95	14	88	63	1	70	25				6.67	+1.5	14		sw.				11	11	9		.0	.0
Birmingham	700	11	48	29.26	29.99	−.02	80.2	.0	95	3	89	68	13	71	26	72	70	80	8.39	+3.2	15	5.8	s.	21	se.	30	5	16	10	6.4	.0	.0
Mobile	57	86	161	29.93	29.99	−.02	81.5	+.1	99	4	88	72	13	74	22	75	72	80	12.83	+5.9	17	8.2	s.	30	ne.	12	2	11	18	7.3	.0	.0
Montgomery	218	92	105	29.76	30.01	−.01	80.8	−.9	96	13	89	68	15	72	25	73	71	78	8.84	+4.0	16	6.4	se.	21	n.	15	3	11	17	7.2	.0	.0
Meridian	375	67	92	29.60	29.98	−.04	82.0	+1.6	98	4	92	68	1	72	27	73	71	78	3.68	−1.2	13	4.7	sw.	22	sw.	15	5	13	13	6.5	.0	.0
Vicksburg	247	82	102	29.72	29.97	−.03	81.3	.0	94	7	90	68	19	73	22	73	71	79	8.31	+3.8	14	6.3	s.	34	n.	5	1	16	14	7.0	.0	.0
New Orleans	53	76	84	29.94	29.99	−.01	82.8	+.4	99	5	90	71	18	75	26	75	74	81	7.85	+1.5	18	5.4	sw.	23	nw.	18	2	17	12	6.3	.0	.0
West Gulf States							**83.2**	**+0.6**										**74**	**3.10**	**−1.2**										**4.7**		
Shreveport	249	92	227	29.71	29.97	−.01	83.6	+.4	101	5	93	71	25	74	25	74	71	76	4.00	+.4	9	7.7	sw.	35	nw.	29	5	16	10	6.0	.0	.0
Bentonville	1,303	12	38	28.59	29.92	−.05	79.2	+.7	96	5	91	64	20	68	28				3.25	−1.1	7	4.5	s.	19	nw.	7	17	9	5		.0	.0
Fort Smith	463	57	82	29.49	29.96	−.01	83.8	+2.3	100	12	94	70	23	73	27	72	66	66	1.34	−2.0	7	5.5	e.	31	sw.	14	13	13	5	4.5	.0	.0
Little Rock	357	94	102	29.58	29.95	−.04	82.8	+1.9	100	4	92	70	23	73	26	73	70	70	2.50	−1.0	9	6.4	e.	27	e.	12	11	9	11	5.4	.0	.0
Austin	605	68	90	29.32	29.95		84.7	+.7	98	17	94	72	3	75	24	74	71	71	1.34	−1.0	7	6.8	s.	19	se.	22	14	12	5	4.2	.0	.0
Brownsville	57	88	96	29.87	29.93		84.0	+.4	93	28	91	73	31	77	20	76	74	79	.04	−1.9	1	11.2	se.	22	s.	16	21	9	1	3.0	.0	.0
Corpus Christi	20	11	78	29.93	29.95	−.01	84.1	+1.4	94	6	90	76	3	78	18	77	75	82	.12	−1.4	2	12.4	s.	26	se.	16	18	12	1	3.4	.0	.0
Dallas	512	220	227	29.40	29.94		83.0		99	5	91	68	8	75	24	72	68	67	1.79	−1.1	10	8.4	s.	47	ne.	8	12	9	10	5.2	.0	.0
Fort Worth	679	92	110	29.25	29.95	−.01	83.6	.0	100	5	93	70	22	75	24				2.16	−.4	9	7.9	s.	21	e.	8	17	7	7	3.3	.0	.0
Galveston	54	106	114	29.92	29.98	.00	83.2	−.2	91	6	88	71	31	79	17	76	74	77	4.00	+.3	10	8.5	s.	28	nw.	31	10	15	6	4.7	.0	.0
Houston	138	292	314	29.84	29.98		83.4	−.3	96	28	92	70	31	75	25				7.37	+3.4	10	8.3	s.	32	n.	20	7	14	10	5.5	.0	.0
Palestine	510	64	72	29.45	29.97	.00	81.5	−.7	98	6	90	70	3	73	28	73	70	76	6.15	+3.5	12	5.8	s.	25	e.	6	10	11	10	5.5	.0	.0
Port Arthur	34	59	134	29.95	29.98		82.5		97	6	90	71	31	75	23	75	73	79	8.43	+1.5	16	8.3	sw.	40	ne.	5	4	17	10	6.5	.0	.0
San Antonio	693	111	301	29.22	29.92	−.03	85.0	+1.2	98	6	95	73	3	75	24	74	69	67	.91	−1.3	4	9.4	se.	31	e.	12	14	15	2	4.2	.0	.0

[1] Observations taken at airport.

TABLE 2.—*Climatological data for Weather Bureau stations, July 1938*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Mi.								0–10	In.	In.
Ohio Valley and Tennessee							77.3	+0.7										72	5.21	+1.4										5.5		
Chattanooga	762	71	214	29.20	29.99	−.03	79.4	+1.0	95	3	89	63	1	70	25	72	69	77	6.85	+2.6	18	6.5	w.	38	nw.	11	5	12	14	6.5	0.0	0.0
Knoxville	995	66	84	28.96	29.99	−.03	78.4	+1.3	94	7	88	63	1	69	26	70	68	75	4.83	+.5	15	4.6	w.	18	n.	11	12	8	11	4.9	.0	.0
Memphis	399	78	86	29.54	29.96	−.04	83.0	+2.3	97	6	91	71	15	75	23	73	70	70	1.78	−1.4	6	6.1	sw.	36	sw.	14	10	12	9	5.5	.0	.0
Nashville	546	168	188	29.43	30.00	−.01	79.2	+.1	95	11	88	66	11	70	29	71	69	77	5.93	+2.0	11	6.0	w.	50	n.	11	8	11	12	6.1	.0	.0
Lexington	989	6																														
Louisville	525	188	234	29.42	29.99	−.01	78.6	.0	97	11	86	65	5	71	29	70	66	71	6.95	+3.2	10	7.6	sw.	43	sw.	11	13	8	10	5.4	.0	.0
Evansville	431	76	116	29.51	29.97	−.03	79.1	+.2	98	11	88	65	11	71	33	70	67	70	5.28	+1.9	9	6.2	sw.	30	ne.	11	10	9	12	5.5	.0	.0
Indianapolis	822	194	230	29.10	29.97	−.02	77.0	+1.3	94	11	86	60	5	68	25	67	62	64	7.15	+3.8	7	7.7	s.	32	n.	27	12	14	5	4.7	.0	.0
Terre Haute	575	63	149	29.34	29.94		79.3		98	11	90	64	5	69	29	69	64	66	4.86	+1.7	9	6.7	sw.	43	n.	11	13	12	6	4.8	.0	.0
Cincinnati	627	11	51	29.31	29.98	−.02	76.2	+1.1	94	11	86	59	5	66	27	68	65	77	6.98	+3.7	12	5.4	sw.	21	nw.	2	12	8	11	5.2	.0	.0
Columbus	822	90	210	29.11	29.96	−.04	76.5	+1.6	95	8	86	57	5	67	27	68	64	69	5.22	+1.7	11	7.2	s.	27	nw.	27	11	13	7	5.4	.0	.0
Dayton	900	186	213	29.03	29.96		75.2	−.2	93	11	85	58	5	66	25	67	63	69	5.87	+2.6	15	7.0	sw.	32	sw.	28	13	11	7	5.0	.0	.0
Elkins	1,947	65	83	28.03	30.01	.00	70.7	+.4	89	8	81	50	4	60	32	65	63	83	6.09	+.7	18	4.5	se.	21	sw.	17	6	13	12	6.3	.0	.0
Parkersburg	637	77	84	29.31	29.98	−.03	75.4	.0	93	8	85	57	5	66	29	69	66	76	3.08	−1.2	11	4.9	se.	25	nw.	13	11	10	10	5.3	.0	.0
Pittsburgh [1]	1,273	39	54	28.64	29.98	−.02	74.5	−.1	93	8	84	55	4	65	27	66	62	70	2.06	−2.0	9	7.9	sw.	22	s.	22	5	10	16	6.5	.0	.0
Lower Lake Region							73.1	+1.6										71	3.30	0.0										5.5		
Buffalo	768	243	280	29.14	29.95	−.02	71.6	+1.8	87	7	78	55	3	66	25	65	62	73	2.06	−1.0	9	11.4	sw.	35	w.	23	9	14	8	5.5	.0	.0
Canton	448	10	61	29.46	29.92		69.8	−.7	89	8	80	45	4	60	31	64	61	74	4.53	+1.0	13	6.9	w.	22	sw.	14	5	11	15	6.5	.0	.0
Ithaca	836	77	100	29.07	29.95		72.5	+2.0	94	26	84	46	7	61	42	65	61	70	2.31	−1.2	11	7.0	nw.	26	nw.	21	2	18	11	6.8	.0	.0
Oswego	335	71	85	29.58	29.94	−.02	71.2	+.8	94	8	79	55	7	64	29	65	62	75	2.91	.0	13	6.6	s.	22	n.	21	10	5	16	6.5	.0	.0
Rochester	523	86	102	29.40	29.96	−.01	73.6	+2.9	94	8	82	57	3	65	32	65	61	70	3.62	+.7	11	7.2	sw.	23	sw.	11	11	9	11	5.2	.0	.0
Syracuse	596	65	79	29.32	29.96	−.01	74.0	+3.4	94	8	83	51	3	65	30				4.02	+.3	10	6.5	s.	23	w.	14	8	13	10	5.9	.0	.0
Erie	714	130	81	29.20	29.95	−.03	73.6	+2.6	93	8	81	56	4	66	26	66	63	71	2.21	−.8	12	6.5	sw.	22	w.	8	14	15	2	3.9	.0	.0
Cleveland	762	267	318	29.15	29.96	−.03	73.6	+2.2	91	8	80	60	4	67	23	65	61	68	3.28	−.2	8	10.9	s.	54	w.	28	11	12	8	4.7	.0	.0
Sandusky	629	5	67	29.29	29.96	−.03	75.1	+1.7	95	8	84	58	5	66	29				4.27	+.8	10	7.2	s.	24	sw.	8	9	11	11	5.5	.0	.0
Toledo	628	79	87	29.30	29.97	−.02	74.6	+1.4	91	7	84	58	15	66	27	66	62	68	2.97	.0	11	7.9	w.	28	w.	22	17	8	6	4.0	.0	.0
Fort Wayne	857	69	84	29.06	29.97		74.0	−.5	90	26	83	59	4	65	25	66	62	69	3.21	−.4	10	7.1	sw.	23	nw.	13	10	15	6	5.1	.0	.0
Detroit [1]	626	5	78	29.28	29.95	−.03	74.0	+1.9	92	7	84	55	3	64	27	66	62	68	4.26	+.9	10	7.8	sw.	26	sw.	26	5	18	8	5.9	.0	.0
Upper Lake Region							69.3	+1.2										76	2.25	−0.9										5.8		
Alpena	609	13	89	29.30	29.96	−.01	68.8	+2.9	92	8	78	49	21	60	28	63	60	75	2.35	−.4	11	8.8	nw.	25	sw.	25	10	15	6	4.8	.0	.0
Escanaba	612	41	49	29.30	29.95	−.02	67.0	+1.0	85	13	75	46	21	59	26	62	60	78	2.09	−1.2	15	8.7	s.	30	ne.	19	4	10	17	6.7	.0	.0
Grand Rapids	707	70	244	29.20	29.95	−.03	73.4	+1.1	90	6	82	55	15	64	26	66	62	70	2.60	−.3	13	8.5	sw.	31	sw.	26	10	12	9	5.3	.0	.0
Lansing	878	5	90	29.03	29.95		71.2	+.3	89	25	81	52	4	62	29	65	62	77	1.50	−1.6	10	6.4	sw.	19	w.	26	7	14	10	5.5	.0	.0
Marquette	734	44	69	29.16	29.95	−.01	65.3	+.4	88	13	73	45	21	57	28	61	59	83	1.54	−1.6	11	5.7	nw	19	sw.	16	6	14	11	6.1	.0	.0
Sault Sainte Marie	614	11	52	29.28	29.97	.00	65.8	+2.0	86	7	76	50	24	56	30	59	56	76	1.78	−1.1	8	6.0	nw.	22	nw.	14	9	12	10	5.3	.0	.0
Chicago	673	7	131	29.25	29.96	−.02	73.8	+1.3	92	25	81	61	24	66	26	67	64	77	3.90	+.6	14	7.6	sw.	30	nw.	13	13	9	9	5.0	.0	.0
Green Bay	617	109	141	29.28	29.95	−.02	71.0	+1.0	87	6	80	50	15	62	27	64	60	71	1.84	−1.6	11	8.6	s.	30	sw.	13	3	12	16	7.1	.0	.0
Milwaukee	681	97	221	29.22	29.95	−.02	71.9	+1.8	90	19	79	57	21	65	28	65	62	74	2.70	−.1	10	10.2	w.	35	sw.	13	7	13	11	5.8	.0	.0
Duluth	1,133	5	47	28.72	29.92	−.03	64.4	+.5	86	29	74	48	2	55	37	59	56	80	2.23	−1.5	13	9.7	ne.	35	nw.	18	6	10	15	6.7	.0	.0
North Dakota							70.5	+2.2										65	3.17	+0.6										4.3		
Moorhead, Minn.	940	50	58	28.92	29.90	−.04	71.2	+3.1	98	31	83	52	23	60	39	63	56	69	1.96	−1.5	9	7.1	s.	24	w.	3	8	12	11	5.4	.0	.0
Bismarck	1,674	8	57	28.19	29.93	.00	72.0	+2.2	95	23	84	52	10	60	35	62	55	61	2.36	+.1	11	7.4	nw.	25	se.	11	11	18	2	3.9	.0	.0
Devils Lake	1,478	11	44	28.38	29.92	−.01	68.9	+1.5	95	30	81	46	25	57	35	61	56	68	4.78	+2.2	11	7.3	nw.	27	nw.	13	8	14	9	5.2	.0	.0
Grand Forks	833	12	67				69.6	+2.1	94	12	82	51	17	58	35	63	58		3.73	+1.0	9	7.0	nw.				8	14	9		.0	.0
Williston	1,878	42	50	27.99	29.92	.00	70.8	+1.9	94	30	83	50	10	59	36	60	55	63	3.01	+1.1	13	6.8	w.	31	w.	4	22	9	0	2.7	.0	.0
Upper Mississippi Valley							77.1	+2.0										70	4.22	+0.7										4.7		
Minneapolis-St. Paul, Minn. [1]	848	32	61	29.02	29.91	−.04	73.4	+1.1	95	12	83	56	23	64	32	66	62	71	3.36	−.4	11	8.5	se.	31	nw.	7	6	18	7	5.9	.0	.0
La Crosse	714	11	48	29.18	29.93	−.03	73.4	+.6	88	12	83	56	23	64	29	67	65	78	7.08	+3.2	15	4.3	w.	18	w.	9	8	14	9	5.4	.0	.0
Madison	974	70	78	28.92	29.94	−.03	72.8	+.7	88	6	81	57	15	64	25	66	62	73	3.43	−.4	13	6.5	nw.	24	ne.	12	6	15	10	6.2	.0	.0
Charles City	1,015	10	51	28.88	29.94	−.02	74.5	+2.2	97	12	85	56	23	64	29	67	64	73	4.57	+.8	12	5.1	se.	19	nw.	9	14	13	4	4.2	.0	.0
Davenport	606	66	161	29.30	29.95	−.02	77.8	+2.5	97	12	88	60	21	68	28	68	64	67	4.83	+1.5	13	8.0	sw.	32	nw.	13	12	12	7	4.4	.0	.0
Des Moines	861	5	99	29.03	29.92	−.04	78.9	+3.5	100	12	90	61	23	68	29	69	64	63	2.49	−1.0	10	8.0	e.	40	sw.	6	17	9	5	3.6	.0	.0
Dubuque	699	60	79	29.20	29.93	−.04	75.9	+1.8	91	6	85	59	23	66	28	68	64	70	2.96	−1.0	11	5.1	nw.	20	ne.	13	8	14	9	5.3	.0	.0
Keokuk	614	64	78	29.30	29.94	−.04	79.4	+2.5	98	12	89	63	18	70	25	70	66	68	1.63	−1.8	9	6.0	sw.	23	nw.	6	12	10	9	4.7	.0	.0
Cairo	358	87	93	29.58	29.95	−.05	80.5	+.9	98	11	89	68	6	72	24	72	68	72	7.47	+4.4	7	6.1	n.	21	se.	12	12	6	13	5.7	.0	.0
Peoria	609	11	45	29.31	29.97	−.01	76.6	+1.2	96	12	88	56	21	66	28	69	66	75	6.34	+2.8	10	4.7	sw.	21	nw.	6	19	10	2	2.9	.0	.0
Springfield, Ill	636	5	191	29.29	29.95	−.03	80.2	+3.7	100	12	91	62	21	70	26	69	64	66	2.83	.0	7	8.9	sw.	34	nw.	7	14	11	6	4.3	.0	.0
St. Louis	568	179	303	29.36	29.94	−.05	81.6	+2.8	101	11	91	67	17	72	24	70	65	62	3.64	+.7	7	9.1	sw.	33	nw.	7	19	6	6	3.6	.0	.0
Missouri Valley							79.6	+3.7										61	3.73	0.0										3.8		
Columbia, Mo.	784	6	66	29.12	29.93	−.05	81.0	+4.1	100	11	92	61	15	70	28				2.60	−0.9	5	6.1	sw.	25	nw.	27	14	12	5	4.1	.0	.0
Kansas City [1]	750	32	45	29.14	29.92	−.05	82.4	+4.3	102	10	93	64	15	72	31	70	64	61	3.82	−.3	7	8.0	sw.	25	nw.	27	18	8	5	3.8	.0	.0
St. Joseph	967	11	49	28.92	29.92		82.0		103	10	93	62	15	71	33	69	63	61	2.85	−.9	7	7.1	s.	32	nw.	1	23	6	2	2.4	.0	.0
Springfield, Mo.	1,324	98	104	28.59	29.95	−.03	80.1	+3.3	96	27	89	66	18	71	24	69	64	64	2.34	−1.9	7	7.2	s.	21	s.	1	14	9	8	4.5	.0	.0
Topeka	987	65	87	28.90	29.92		82.2	+4.0	104	3	94	64	18	70	32	70	65	62	3.97	−.3	6	7.5	s.	21	se.	6	17	10	4	3.6	.0	.0
Lincoln	1,189	11	81	28.68	29.90	−.05	80.8	+4.3	105	12	94	60	21	68	35	67	60	56	2.20	−1.6	9	8.3	s.	43	nw.	6	17	10	4	3.6	.0	.0
Omaha [1]	982	31	44	28.89	29.91	−.04	80.4	+3.7	107	11	93	62	21	68	36	69	64	62	6.84	+3.3	11	8.2	s.	52	w.	6	15	11	5	3.9	.0	.0
Valentine	2,598	47	54	27.29	29.95	+.02	75.2	+1.5	99	11	88	55	7	62	39	63	56	58	2.99	.0	10	7.4	n.	30	n.	6	13	14	4	4.3	.0	.0
Sioux City	1,138	64	106	28.72	29.90	−.05	78.3	+4.0	100	12	90	59	20	67	32	67	62	63	6.70	+3.2	14	7.2	s.	44	nw.	7	15	12	4	3.6	.0	.0
Huron	1,307	59	74	28.56	29.93	−.01	76.0	+4.2	101	31	89	54	23	63	42	64	57	59	2.99	−.2	11	7.7	n.	29	nw.	7	14	12	5	4.5	.0	.0
Northern Slope							69.8	+2.2										56	1.50	0.0										4.3		
Havre	2,507	11	67	27.38	29.97	+.06	70.8	+2.5	97	22	84	53	1	58	38	58	50	57	2.43	+.6	9	6.6	w.	35	sw.	8	13	13	5	4.3	.0	.0
Helena	4,124	85	111	25.88	29.99	+.06	67.2	+1.5	91	22	79	47	3	55	34	55	47	54	1.91	+.8	11	7.3	sw.	24	sw.	2	18	9	9	4.9	.0	.0
Missoula	3,263	80	91				71.0	+3.4	100	22	85	51	7	57	39				.66	−.3	9	6.8	se.	26	e.	23	18	3	10	3.9	.0	.0
Kalispell	2,973	48	56	26.97	29.96	+.03	68.0	+3.9	97	22	82	46	9	54	38	55	47	55	1.06	.0	8	5.7	nw.	20	ne.	16	15	8	8	4.2	.0	.0
Miles City	2,371	48	55	27.50	29.94	+.02	73.8	+.9	97	23	86	54	6	62	35	60	52	54	.89	−.6	13	5.8	s.	32	nw.	3	15	11	5	3.9	.0	.0
Rapid City	3,259	50	58	26.66	29.94	+.01	73.6	+2.6	99	31	86	56	27	61	34	60	53	54	1.56	−.8	10	7.3	w.	22	ne.	25	15	14	2	3.6	.0	.0
Cheyenne [1]	6,144	5	39	24.09	29.97	+.05	68.0	+1.3	95	31	83	45	7	53	42	54	47	57	1.32	−.8	13	9.0	nw.	31	nw.	13	11	18	2	4.9	.0	.0
Lander	5,352	60	68	24.76	29.96	+.04	68.5	+1.1	96	31	84	43	7	53	41	52	41	45	.78	+.1	10	5.5	sw.	25	se.	19	18	16	2	4.3	.0	.0
Sheridan	3,790	10	47	26.17	30.00		69.0		94	11	84	45	22	54	48	58	52	64	1.36	+.1	8	4.2	s.	22	nw.	23	21	5	5	3.5	.0	.0
Yellowstone Park	6,241	12	46	24.04	30.11	+.19	61.1	+.2	84	10	75	40	6	48	36	49	42	61	1.35	+.1	18	7.1	sw.	30	nw.	8	11	10	10	5.3	.0	.0
North Platte	2,821	11	51	27.08	29.93	.00	77.1	+4.2	103	12	90	57	6	64	34	64	58	61	3.15	+.4	12	6.4	e.	27	nw.	6	14	7	10	4.7	.0	.0

[1] Observations taken at airport.

TABLE 2.—*Climatological data for Weather Bureau stations, July 1938*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Mile								0-10	In.	In.
Middle Slope							79.1	+2.0										55	1.96	−0.8										3.6		
Denver	5,292	106	113	24.84	29.98	+0.07	72.4	+0.2	95	31	85	54	7	60	31	56	45	47	0.56	−1.1	9	7.4	s.	33	ne.	19	11	17	3	4.0	0.0	0.0
Pueblo	4,685	80	86	25.37	29.94	+.03	75.8	+1.6	100	31	90	55	24	62	38	58	48	48	1.61	−.3	10	6.9	nw.	27	s.	27	17	13	1	3.6	.0	.0
Concordia	1,392	50	58	28.49	29.92	−.03	81.3	+3.3	103	12	93	62	18	69	33	69	63	50	2.86	−.9	9	7.4	s.	28	nw.	1	17	12	2	3.3	.0	.0
Dodge City	2,509	10	86	27.38	29.91	−.02	80.8	+2.4	103	1	93	61	21	68	31	66	58	55	1.71	−1.4	7	10.6	s.	34	sw.	13	18	11	2	3.7	.0	.0
Wichita	1,358	85	93	28.53	29.92	−.04	82.2	+2.8	102	2	93	65	18	71	27	68	62	57	2.24	−1.1	7	9.2	s.	28	ne.	13	21	7	3	2.9	.0	.0
Oklahoma City	1,214	10	47	28.68	29.92	−.04	82.1	+1.5	99	6	93	67	19	72	30	71	66	65	2.75	−.1	6	7.6	s.	20	w.	7	14	11	6	4.4	.0	.0
Southern Slope							81.3	+0.1										59	3.54	+1.1										4.1		
Abilene	1,738	10	56	28.16	29.92	−.01	83.0	+.2	103	7	94	68	25	72	33	70	64	62	7.95	+5.8	9	8.1	s.	29	se.	8	15	7	9	4.6	.0	.0
Amarillo	3,676	10	49	26.30	29.94	+.02	79.2	+2.4	101	31	90	62	24	68	32	64	58	57	1.88	−1.0	11	8.4	s.	24	ne.	19	11	15	5	4.2	.0	.0
Del Rio	960	63	71	28.91	29.86	−.04	85.6	−.7	100	6	95	71	24	76	24	71	65	58	2.78	+.4	7	9.2	se.	27	e.	8	17	8	6	4.1	.0	.0
Roswell	3,566	75	85	26.39	29.92	+.04	77.4	−1.5	99	31	89	57	22	65	35	64	58	59	1.56	−.7	12	6.7	s.	26	sw.	13	15	13	3	3.6	.0	.0
Southern Plateau							80.5	−0.4										45	0.97	−0.2										3.2		
El Paso	3,778	82	101	26.20	29.88	+.04	80.6	−.5	99	7	92	63	24	69	35	63	54	49	.60	−1.4	11	7.3	e.	26	se.	14	19	6	6	3.5	.0	.0
Albuquerque [1]	4,972	5	30	25.10	29.87	-----	75.9	−.8	97	31	90	56	6	61	37	59	50	49	1.45	.0	6	7.7	se.	41	n.	18	16	11	4	3.5	.0	.0
Santa Fe	7,013	38	53	23.39	29.96	+.08	68.9	−.1	90	31	81	49	19	57	30	53	43	49	3.29	+.9	9	5.6	e.	29	s.	13	8	14	9	5.3	.0	.0
Flagstaff	6,907	10	59																													
Phoenix	1,107	39	51	28.69	29.80	+.02	90.3	+.5	112	31	104	67	5	77	39	68	54	35	.25	−.8	3	6.5	w.	27	nw.	20	24	5	2	2.4	.0	.0
Yuma	141	9	54	29.66	29.80	+.04	90.6	−.2	112	31	106	63	6	76	44	71	59	41	.18	.0	3	5.8	s.	26	n.	21	24	7	0	1.5	.0	.0
Independence	3,957	5	26	25.99	29.94	+.11	76.6	−1.5	101	22	93	53	3	61	40	56	40	----	.04	−.1	1	------	n.	----	------	---	19	11	1	----	.0	.0
Middle Plateau							72.8	+0.6										39	0.80	+0.3										2.8		
Reno	4,527	61	76	25.52	29.96	+.09	71.6	+1.5	100	22	88	46	4	56	40	55	44	45	.24	.0	2	6.3	w.	22	w.	24	22	7	2	2.8	.0	.0
Tonopah	6,090	12	20	------	------	------	73.7	------	94	19	87	50	4	60	39	53	38	33	.31	.0	5	7.8	se.	24	se.	8	---	---	---	2.9	.0	.0
Winnemucca	4,344	18	56	25.66	29.97	+.07	71.7	+1.1	101	23	89	43	3	54	48	54	41	44	1.15	+.9	4	6.9	sw.	25	sw.	2	19	6	6	3.4	.0	.0
Modena	5,473	10	43	24.68	29.90	+.04	70.2	−.4	94	31	87	40	5	54	44	52	37	37	2.22	+1.1	5	9.8	sw.	32	sw.	24	23	6	2	2.3	.0	.0
Salt Lake City [1]	4,227	32	46	25.76	29.92	+.02	73.8	------	101	31	89	44	6	59	41	57	47	44	.51	------	4	9.4	se.	36	ne.	21	18	9	4	3.2	.0	.0
Grand Junction	4,602	60	68	25.42	29.93	+.04	77.7	.0	101	31	92	58	7	64	34	56	41	33	.14	−.5	4	6.9	se.	31	se.	22	22	8	1	2.5	.0	.0
Northern Plateau							74.5	+3.9										41	0.43	−0.1										3.0		
Baker	3,471	36	54	26.49	29.99	+.04	69.6	+4.0	98	21	86	42	4	54	42	55	45	48	.60	.0	6	5.7	s.	24	sw.	28	15	10	6	4.1	.0	.0
Boise	2,739	79	87	27.16	29.95	+.02	75.0	+2.1	102	22	89	52	5	62	36	59	48	45	.85	+.6	6	4.8	se.	18	se.	15	18	8	5	3.6	.0	.0
Pocatello	4,477	60	68	25.54	29.96	+.04	70.0	−.8	96	30	84	46	4	56	40	54	44	48	.81	.0	8	8.0	se.	27	s.	2	16	10	5	3.8	.0	.0
Spokane	1,929	101	110	27.94	29.94	−.02	75.0	+6.0	103	22	89	50	3	61	41	57	43	39	.26	−.4	2	6.6	s.	21	sw.	8	20	8	3	2.4	.0	.0
Walla Walla	991	57	65	28.88	29.92	−.05	79.5	+5.5	108	21	92	56	2	67	37	59	43	32	T	−.4	0	5.8	s.	19	sw.	28	22	6	3	2.3	.0	.0
Yakima	1,076	58	67	28.81	29.93	------	78.1	+6.7	106	22	92	54	2	64	35	59	44	35	.04	−.3	2	7.0	nw.	24	nw.	18	24	6	1	1.8	.0	.0
North Pacific Coast Region							66.2	+2.7										66	0.28	−0.4										3.5		
North Head	211	11	56	29.87	30.09	+.01	56.0	−1.2	76	14	60	49	9	52	24	54	52	90	.44	−.5	5	13.3	nw.	35	nw.	7	11	9	11	5.7	.0	.0
Seattle	125	90	321	29.91	30.04	.00	67.3	+4.2	92	21	78	51	1	57	31	58	51	61	.18	−.4	2	7.2	n.	20	n.	12	19	6	6	3.3	.0	.0
Tacoma	194	172	201	29.85	30.05	−.01	65.8	+3.0	87	21	76	50	2	56	27	------	------	----	.30	−.3	3	7.2	n.	24	n.	14	18	9	4	3.1	.0	.0
Tatoosh Island	86	10	54	29.99	30.09	+.04	54.0	−1.1	72	21	58	47	9	50	20	52	50	89	.72	−.8	7	9.9	sw.	29	sw.	26	11	7	13	5.5	.0	.0
Medford [1]	1,329	29	58	28.58	29.95	------	76.4	+4.7	108	20	94	46	3	59	46	60	48	45	.03	−.3	2	------	w.	----	------	---	24	5	2	1.5	.0	.0
Portland, Oreg.	154	68	106	29.86	30.02	−.03	71.0	+4.3	101	20	83	50	5	59	34	60	53	57	.25	−.4	3	6.3	nw.	17	nw.	7	19	7	5	3.0	.0	.0
Roseburg	510	45	76	29.46	30.00	−.03	72.6	+5.2	104	20	88	47	5	57	43	60	51	54	.05	−.3	1	5.0	n.	18	n.	19	23	6	2	2.1	.0	.0
Middle Pacific Coast Region							68.3	+1.0										64	T	0.0										3.7		
Eureka	60	72	88	29.97	30.04	−.01	55.3	−.2	65	10	59	48	1	51	15	53	51	87	T	−.1	0	6.3	nw.	18	n.	4	3	11	17	6.7	.0	.0
Redding [1]	722	20	34	------	------	------	83.6	+1.8	113	19	97	56	2	70	33	62	47	33	.00	−.1	0	7.2	nw.	18	nw.	20	26	4	1	1.9	.0	.0
Sacramento	66	92	115	29.82	29.89	+.01	75.4	+2.2	106	20	92	51	3	59	42	61	53	53	T	.0	0	7.9	s.	22	sw.	1	27	4	0	.8	.0	.0
San Francisco	155	112	132	29.80	29.97	+.02	58.8	+.3	74	31	63	51	6	54	18	55	53	85	.01	.0	1	11.0	w.	26	w.	9	7	15	9	5.5	.0	.0
South Pacific Coast Region							72.9	−0.2										64	T	0.0										2.9		
Fresno	327	97	105	29.53	29.87	+.04	82.4	+.3	109	20	99	56	3	66	37	63	48	37	T	.0	0	7.1	nw.	17	nw.	18	28	3	0	1.1	.0	.0
Los Angeles	338	159	191	29.59	29.95	+.05	69.6	−.6	85	31	79	56	9	60	23	62	58	74	.00	.0	0	5.4	sw.	14	w.	27	18	13	0	2.7	.0	.0
San Diego	87	62	70	29.85	29.94	+.02	66.8	−.4	77	22	71	58	9	62	12	62	60	81	T	.0	0	7.1	w.	15	w.	26	10	16	5	4.8	.0	.0
West Indies																																
San Juan, P. R.	82	9	54	29.95	30.04	------	79.6	−.5	90	6	84	73	10	76	15	----	----	----	5.10	−.8	14	14.0	e.	36	e.	30	10	20	1	4.1	.0	.0
Panama Canal																																
Balboa Heights	118	6	92	------	[3]29.85	+.03	80.0	−.3	89	14	86	70	7	74	17	----	----	[2]87	7.52	+.2	24	5.5	nw.	30	n.	9	0	21	10	7.0	.0	.0
Cristobal	36	6	97	------	[3]29.87	+.03	80.4	.0	88	1	85	72	16	76	13	76	75	[2]87	22.25	+6.6	29	6.9	w.	28	nw.	19	0	0	31	9.1	.0	.0
Alaska																																
Fairbanks	454	11	87	[3]29.41	[3]29.91	------	59.2	−.8	85	25	70	40	29	48	37	53	49	73	2.72	+.8	11	6.0	s.	27	s.	12	7	11	13	6.6	.0	.0
Juneau	80	96	116	[3]29.98	[3]30.07	------	54.7	−2.4	75	25	60	43	15	49	25	51	47	79	7.29	+2.2	23	6.7	se.	19	se.	8	5	2	24	8.2	.0	.0
Nome	22	5	32	[3]29.92	[3]29.94	------	49.8	−.2	64	28	55	35	21	44	24	48	46	86	1.43	−1.4	12	7.2	sw.	21	nw.	31	2	5	24	8.5	.0	.0
Hawaiian Islands																																
Honolulu	38	86	100	29.98	30.02	------	77.9	+.2	86	25	82	68	1	74	13	70	66	70	2.35	+1.2	15	9.2	e.	22	e.	14	12	16	3	4.6	.0	.0

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District and station	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Total	Departure from normal	Days with 0.01 inch or more	Average hourly velocity	Prevailing direction	Miles per hour	Direction	Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Lexington, Ky.	989	6	----	------	------	------	70.9	−1.9	91	22	82	51	14	59	34	----	----	----	3.06	−1.0	10	------	sw.	----	------	---	16	8	6	----	.0	.0
Balboa Heights	118	6	92	------	[3]29.85	+.02	78.8	−1.3	90	4	84	71	19	74	16	----	----	[2]88	9.49	+1.2	24	5.2	nw.	28	s.	11	0	17	13	7.3	.0	.0
Cristobal	36	6	97	------	[3]29.86	+.03	80.4	.0	89	11	85	73	18	76	14	76	75	[2]88	18.01	+4.1	27	6.3	w.	21	n.	27	0	3	27	9.1	.0	.0

[1] Observations taken at airport.
[2] Observations taken bihourly.
[3] Pressure not reduced to a mean of 24 hours.

TABLE 3.—*Data furnished by the Canadian Meteorological Service, July 1938*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Temperature of the air: Departure from normal	Temperature of the air: Mean maximum	Temperature of the air: Mean minimum	Temperature of the air: Highest	Temperature of the air: Lowest	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Total snowfall
	Feet	In.	In.	In.	°F.	°F.	°F.	°F.	°F.	°F.	In.	In.	In.
Cape Race, Newfoundland	99												
Sydney, Cape Breton Island	48	29.92	29.97	+0.03	66.0	+2.1	74.7	57.3	85	44	3.57	+0.13	0.0
Halifax, Nova Scotia	88	29.75	30.01	+.05	64.7	-.1	71.6	57.8	86	51	5.36	+1.52	.0
Yarmouth, Nova Scotia	65	29.89	29.99	+.03	60.2	-.5	67.3	54.2	78	47	5.47	+2.01	.0
Charlottetown, Prince Edward Island	38	29.89	29.97	+.05	66.9	+1.8	73.6	60.2	82	50	5.08	+2.04	.0
Chatham, New Brunswick	28	29.80	29.91	+.01	66.3	-.1	75.4	57.2	87	47	3.77	-.26	.0
Father Point, Quebec	20												
Quebec, Quebec	296	29.60	29.92	+.02	67.7	+1.0	75.3	60.1	87	48	5.33	+1.13	.0
Doucet, Quebec	1,236	28.59	29.92	+.01	60.6	+2.1	73.8	47.4	87	32	7.43	+2.40	.0
Montreal, Quebec	187												
Ottawa, Ontario	236	29.68	29.92	.00	69.2	+.4	79.9	58.4	87	45	5.29	+1.90	.0
Kingston, Ontario	285	29.62	29.93	-.01	69.1	+.7	75.7	62.5	81	53	4.41	+1.46	.0
Toronto, Ontario	379	29.54	29.94	-.02	71.8	+2.5	81.4	62.2	92	53	2.62	-.26	.0
Cochrane, Ontario	930	28.92	29.92	+.02	62.2	-.4	73.7	50.8	87	40	4.82	+1.40	.0
White River, Ontario	1,244	28.64	29.96	+.04	61.0	+.4	75.2	46.9	88	32	4.30	+1.19	.0
London, Ontario	808	29.10	29.96	-.02	70.2	+1.0	80.9	59.4	89	47	4.32	+1.26	.0
Southampton, Ontario	656	29.26	29.96	-.02	68.0	+2.5	77.1	59.0	89	45	2.22	-.16	.0
Parry Sound, Ontario	688	29.26	29.94	.00	69.2	+2.2	78.3	60.0	89	51	1.94	-.73	.0
Port Arthur, Ontario	644	29.24	29.94	+.01	60.6	-2.3	70.5	50.8	82	39	2.49	-1.02	.0
Winnipeg, Manitoba	760	29.08	29.90	-.03	68.6	+1.9	79.4	57.7	93	48	4.08	+1.01	.0
Minnedosa, Manitoba	1,690	28.15	29.93	+.03	66.6	+2.9	79.8	53.4	93	40	1.00	-1.49	.0
Le Pas, Manitoba	860	29.95	29.90	+.01	66.0	+1.7	76.0	55.0	89	47	1.74	-.58	.0
Qu'Appelle, Saskatchewan	2,115	27.69	29.92	.00	66.6	+2.6	80.5	52.6	95	39	.96	-1.71	.0
Moose Jaw, Saskatchewan	1,759	27.98	29.93	+.07	69.0	+3.4	82.3	55.6	95	45	1.78	-.34	.0
Swift Current, Saskatchewan	2,392	27.44	29.94	+.04	68.6	+2.9	83.1	54.1	95	45	.81	-1.55	.0
Medicine Hat, Alberta	2,365	27.50	29.96	+.08	68.7	-.5	83.2	54.2	99	41	1.38	-.42	.0
Calgary, Alberta	3,540	26.38	29.98	+.06	63.0	+2.3	75.1	50.9	93	42	3.06	+.46	.0
Banff, Alberta	4,521												
Prince Albert, Saskatchewan	1,450	28.40	29.93	+.02	66.7	+3.7	77.9	55.6	91	47	2.36	+.09	.0
Battleford, Saskatchewan	1,592	28.24	29.94	+.03	66.6	+3.2	80.9	52.2	94	44	1.78	-.42	.0
Edmonton, Alberta	2,150	27.72	29.98	+.10	63.9	+2.5	76.6	51.2	89	40	3.20	-.08	.0
Kamloops, British Columbia	1,262	28.66	29.98	+.04	73.6	+3.8	88.3	59.0	101	52	.57	-.45	.0
Victoria, British Columbia	230	29.81	30.05	+.01	60.6	+.7	68.9	52.3	84	47	.41	.00	.0
Barkerville, British Columbia	4,180												
Estevan Point, British Columbia	20	30.07	30.10	+.02	55.8	+.4	61.6	50.0	67	43	2.10	-.82	.0
Prince Rupert, British Columbia	170	29.93	30.11	+.03	56.0	.0	63.0	49.0	76	44	2.99	-1.88	.0
St. George's, Bermuda	158		30.20	+.06	79.9	+1.4	85.9	74.0	89	68	6.31	+2.53	.0

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Cape Race, Newfoundland	99				47.8	+0.2	55.1	40.5	73	33	3.30	-1.06	0.0

TABLE 4.—*Severe local storms, July 1938*

[Compiled by Mary O. Souder from reports submitted by Weather Bureau officials]

[The table herewith contains such data as has been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the United States Yearbook]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Dover, Minn., and vicinity	1	A. m.			$6,125	Rain and flood	2 bridges washed out; basements flooded; highways and lowlands inundated; some damage to crops. Property damage $6,125.
Gretna, Kans., vicinity of	1	3 p. m.	[1] 3		25,000	Heavy hail	Loss principally to crops; path 10 to 15 miles long.
Franklin, Nebr.	1	4 p. m.	880		500	Hail	Property damage.
David City, Nebr., 3 miles south.	1	4:30 p. m.	[1] 2		25,000	do	Do.
Norway and Talmo, Kans., vicinity of.	1	4:30-8:30 p. m.	[1] 2½		10,000	Heavy hail	About 2,000 acres of crops affected; path 10 miles long.
Roberts, Mont., 6 miles south	1	7:30-8 p. m.	[1] 2		50,000	Hail	Loss to wheat crop.
Osessa, Wash., vicinity of	1					do	Considerable damage in small area.
Indianapolis, Ind.	2	11:55 a. m.-4:18 p. m.				Thunderstorm	Streets and basements flooded; sewers inadequate; much damage reported.
Fairfield, Idaho, 7 miles southeast.	2	3 p. m.	440	0	500	Tornado	1 granary and 2 small sheds demolished.
Wibaux, Mont., vicinity of	2	do	[1] 6-8		35,000	Hail	Loss to crops $25,000; to buildings $10,000; path 20 miles long.
McCook and Culbertson, Nebr.	2	3:45-4 p. m.	[1] 4		50,000	Hail and high wind.	Barns, sheds, windmills, and trees blown over.
Coalwood, Mont., vicinity of	2	6 p. m.	[1] 5-6		5,000	Hail	50 percent crop loss; path 20 miles long.
Dawson County, Mont., western portion.	2	7:30 p. m.	[1] 3		10,000	do	Loss to crops.
Fallon County, Mont., southwestern portion.	2	do	[1] 3		15,000	do	Loss to crops; path 15 miles long.
Blaine County, Mont., southern portion.	2				25,000	Flood	Bridges, roads, and other property damaged.
Portsmouth, Ohio, and vicinity	2					Heavy rain	5.53 inches of rain fell between 4-9 p. m.
Preble County, Ohio	2					Heavy showers	Streams overflowed; traffic interrupted along Route 35. Sycamore Falls resort damaged by overflow of creek. Corn, tobacco, and shocked wheat damaged.
Minnehaha and Moody, Counties, S. Dak.	2				16,500	Flood	Damaged highway bridges $10,000; crop loss $5,000; livestock and other property, $1,500.
Pryor Valley, in Big Horn and Yellowstone Counties, Mont.	3	5 p. m.	[1] 2½-3		8,000	Hail	Loss to crops between $5,000 and $7,000; damage to roofs, windows, and livestock, $1,000.
Prairie County, Mont.	3	6-9:30 p. m.	[1] 10-20		20,000	do	Loss to crops; path 42 miles long.
Rosebud, Garfield, Prairie, and Custer Counties, Mont.	3	8-10 p. m.	[1] 3-5		6,550	Wind and hail	Loss to grain crop, $6,000; damage to buildings, $550.
Golden Valley and Musselshell Counties, Mont.	3		[1] 1½			Heavy hail	Amount of damage not reported; path 14 miles long.
Wolf Point, Mont., vicinity of	3				14,000	Flood	Loss to prospective crops, $10,000; property damage, $4,000.
Scott, Sibley, Dakota, Hennepin, Wright, and Carver Counties, Minn.	4	1-5 p. m.			86,000	Thunderstorm and hail.	Crop loss from hail, $55,500. Large barn and small outbuildings destroyed; several moved from foundations; trees, telephone, and power lines down; grain and corn lodged.
Cassia and Twin Counties, Idaho.	4	2-4 p. m.	[1] 4		200,000	Heavy hail and high wind.	Hail damage to crops ranged from light to severe; considerable hay damaged by heavy rain; path 15 miles long.
Biddle, Mont., vicinity of	4	2:30 p. m.	[1] 3		4,000	Hail	Loss to crops; path 9 miles long.
Custer and Rosebud Counties, Mont.	4	3 p. m.	[1] 1-4		4,500	Hail and wind	Loss to crops, $4,000; damage to roofs and windows, $500.
Tampa, Fla., vicinity of	4	6:57-7:10 p. m.		0		Small tornado	No damage known. Path narrow.
Cherokee County, Iowa, northwestern portion.	4				2,500	Wind, rain, electrical.	House, 2 corn cribs, and hog house demolished. Trees felled. Loss to crops.
Helena, N. Y.	5	3:30-3:50 p. m.	[1] 1			Heavy hail	Much damage to roofs and windows. Some loss to corn and oats.
Madison, Nebr.	5	5 p. m.	[1] 3		15,000	Hail	Property damage.
Lebanon, Nebr.	5	6 p. m.	[1] 2½		10,000	do	Do.
Gregory, S. Dak.,[2] 10 miles northeast.	5					Rain and hail	Crops total loss.
Broadland and Hitchcock, S. Dak., and vicinities.	6	Noon				Heavy rain and hail.	Loss to crops over narrow path 11 miles long.
Iowa, northwestern and western counties.	6	1 p. m.	[1] 15-20			Thunderstorm and hail.	Trees and communication lines blown down. Pavements and sewers washed out at Sioux City. Hail loss to crops in northwestern counties; but greatest damage caused by heavy rain.
Iowa, south-central and southeastern counties.	6	1-3 p. m.		1		Electrical	Considerable damage to property and loss to crops. Trees and communication lines blown down. Barn burned. 3 persons injured.
Fort Collins, Colo.	6	1:45 p. m.	880-1,760			Heavy hail	40 percent loss to fruit crop; considerable loss to vegetables and grains.
Fountain City, Wis.	6	3:30 p. m.			10,000	Heavy rain	Torrents of water poured through streets carrying tons of mud and rocks. Basements filled with mud, pavements torn up and retaining walls undermined.
Ysleta, Tex., vicinity of	6	3:45 p. m.	[1] 1		5,000	Hail	Loss to crops; path 2½ miles long.
Dubuque, Iowa, vicinity of	6	4 p. m.				Electrical and wind.	Trees uprooted; communication lines blown down. Loss to crops and gardens.
Manchester, Iowa	6	do			3,000	Electrical	Large barn burned.
Broken Bow and Arnold, Nebr.	6	5-7 p. m.	[1] 4		50,000	Hail and high wind.	Property damage.
Russell, Kans., 12 miles northwest.	6	6 p. m.				Heavy hail	Storm severe, but covered small area.
Ravenna, Nebr.	6	8:30-10 p. m.	[1] 10		50,000	Hail and high wind.	Considerable damage to buildings by wind.
Beresford, S. C	6	P. m.	[1] 2			Wind, rain, and hail.	Much loss to small grains and corn; path 7 to 8 miles long.
Oshkosh, Nebr., and vicinity	7	3-4:30 p. m.	[1] 10		20,000	Hail	Property damage.
Shamrock, Tex., vicinity of	7	4-5 p. m.	[1] 2		25,000	do	Loss to crops; path 10 miles long.
Arcadia, Nebr., vicinity of	7	8:30 p. m.	[1] 1		5,000	do	Property damage.
Cold Springs, Okla., and vicinity.	7		[1] 1		500	do	Loss to crops $500; path 3 miles long.
Woodward, Okla., vicinity of	7					Electrical	Barn containing several thousand dollars' worth of experimental grain struck by lightning and destroyed.
Menard, Mont.	8	2 p. m.	[1] 1½		1,000	Hail	Loss to crops; path 4 miles long.
Staten Island, N. Y.	8	8:15 p. m.				Thunderstorm	Traffic delayed; sewers overflowed or backed up stalling automobiles and flooding cellars. Several thousand dollars damage reported.
New York, N. Y.	8	P. m.				do	Traffic delayed; considerable property damage; cellars flooded.
White, S. Dak., and vicinity	9	5:40-6:05 p. m.	110-220	0	16,000	Tornado	Property damage $15,000; loss to crops $1,000; 1 person injured.
Parkersburg, W. Va.	9	6-8 p. m.				Heavy rain and flood.	Much minor damage to streets and cellars in northern and eastern wards

[1] Miles instead of yards.
[2] From press reports.

TABLE 4.—*Severe local storms, July 1938*—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Minnesota, extreme southern counties.	9	6-10 p. m.		0	$693,000	Tornado and hail.	Barns, outbuildings, silos, windmills, garages, demolished or badly damaged; houses unroofed; small buildings moved from foundations; poles and wires down; some livestock and much poultry killed; grain and corn badly lodged. Wind damage $400,500; hail damage chiefly to crops $292,500 over wide area. Width of path 67 yards near Hendricks.
Dozier, Ala.	9					Electrical	High school building struck by lightning and destroyed.
Tampa, Fla., and vicinity	9				600	do	Property damage.
Chickasaw, Bremer, and Howard Counties, Iowa.	9					Rain, wind, and hail.	Loss to crops; light and telephone service impaired; trees damaged.
Melstone, Mont.	9		[1] 4			Hail	Path 8 miles long; no details.
Rothiemay, Mont.	9		[1] 2			do	Path 10 miles long; no details.
Albany, N. Y.	9					Thundersquall	Streets, stores, and cellars flooded. Chimneys and tension wires blown down; a roof caved in by rain; several buildings struck by lightning.
Brasher Falls, N. Y.	9				3,000	Electrical	Large barn burned.
Ogdensburg, N. Y.	9				3,000	do	Do.
Andover, S. Dak.	9			2		Tornado	18 persons injured. 7 houses and a church leveled; communication dis rupted; path about 10 miles long.
Judith Basin and Fergus Counties, Mont.	10	7 p. m.	[1] 5		80,000	Hail	Loss to crops; path 20 miles long.
Trenton, Mich., vicinity of	10	10:30 p. m.	[1] 1	0		Tornado	Considerable damage; path 3 miles long.
Buffalo, N. Y., and vicinity	10			1		Torrential rain and electrical.	Streets flooded; poles and wires down; traffic delayed; several thousand dollars property damage; 10 persons injured.
Detroit, Mich.	11	A. m.			150,000	Thunderstorm and wind.	Heavy damage to trees and power and communication lines. Storage tanks struck by lightning, causing $150,000 damage.
Halifax County, Va., northern portion.	11	2 p. m.			5,000	Heavy hail	Loss to tobacco crop.
Poughkeepsie, N. Y., vicinity of	11	3 p. m.			1,000	Hail	Loss to crops.
Andover, S. Dak., and vicinity.	11	3:30-4:30 p. m.	200-880	3	55,000	Tornado	15 persons injured; buildings wrecked; crops flattened; communication lines tangled; stock killed.
Do	11	do	[1] 7-10		100,000	Heavy rain and hail.	Complete loss to crops. Large hailstones a foot deep in places.
Westervelt, Ill., vicinity of	11	4 p. m.	100	0	3,750	Tornado	Property damage $750; crop loss $3,000; path 10 miles long.
Lustre, Mont., vicinity of	11	6-7 p. m.	880-1,760			Hail	Considerable loss to crops. No details.
Washington, Ind., and vicinity.	11	6:30 p. m.	[1] 6	3	250,000	Tornadic winds and rain.	Roofs torn from buildings; trees blown down. Smokestack demolished.
Evansville, Ind	11	6:50 p. m.			3,000	Thunderstorm and dust.	Property damage. Wind velocity rose from 4 miles per hour at 6:10 p. m. to 37 miles per hour at 6:44 p. m. Local dust-storm preceded the rain.
Tennessee, central, and eastern counties.	11	9 p. m.			70,000	Thundersquall	Considerable damage to communication systems, trees, windows, and crops. Greatest loss around Nashville and Clarksville.
Chattanooga, Tenn	11	11:30 p. m.				Wind	Wind velocity of 50 miles per hour reported. Windows broken; branches twisted from trees; power service disrupted.
Cannelton, Ind.	11	P. m.		0	2,000	Tornado	Narrow path; no details.
Edwardsport, Ind.	11	do			2,000	Electrical and straight-line winds.	House destroyed.
Jasper, Ind.	11	do				Straight-line winds.	Police radio tower, built to stand 100-mile wind, blown over. Loss to greenhouses and trees.
Humboldt, Ill.	11				45,500	Heavy hail	Damage to buildings, livestock, and poultry $12,000; loss to crops $33,500.
Hutsonville, Ill.	11				2,000	Wind	Property damage.
Palestine, Ill.	11				20,000	do	Property damage $10,000; crop loss $10,000.
Sullivan and Green Counties, Ind.	11				75,000	do	Damage in Sullivan Co., $75,000; in Green County trees uprooted, farm buildings damaged.
Granville County, N. C., northern portion.	11					Hail	Loss to tobacco crops.
Reading, Pa., vicinity of	11-12	3:25 p. m. of 11th-5:30 a. m. of 12th.				Thundersquall and hail.	2.05 inches of precipitation fell. Thousands of dollars loss to crops and much damage to property in Berks County. At Princeton, large hailstones fell for 20 minutes. Trees leveled, hundreds of birds killed, windows smashed and shutters and porch furniture carried for as much as ½ mile, throughout rural district.
McCone County, Mont	11-12	8:30 p. m. of 11th-2 a. m. of 12th.	[1] 10		100,000	Hailstorms	Loss to wheat, oats, corn, and other crops. Light loss to buildings and livestock; path 29 miles long.
Knoxville, Tenn	11-12	9:52 p. m. of 11th-12:30 a. m. of 12th.				Thunderstorm	Telephone communication completely disrupted. Many sections of city without lights. Trees damaged.
Winona, Minn., and vicinity	12	8:30 p. m.	[1] 10		18,000	Thundersquall and hail.	Several small buildings wrecked; silos and windmills damaged; trees uprooted and branches broken off; wires down; 3 cattle killed; some grain and corn lodged. Hail loss to crops $10,000; path 35 miles long.
Allenville, Ill., vicinity of	12		100	0	47,150	Tornadic winds and electrical.	11 freight cars blown off track; buildings on 3 farms leveled; path 6 miles long. Property damage $37,150; crop loss $10,000.
Sullivan, Ill.	12				1,150	Hail	Property damage $750; crop loss $400.
Dayton, Ohio	13	10:55-11:30 a. m.			1,500	Thunderstorm	Church damaged by lightning.
Cawker City, Kans., and vicinity.	13	6:30-7:15 p. m.	[1] 6			Heavy hail	No details.
Chicago, Ill.	13	P. m.			1,500	Electrical	$1,500 damage to cleaning plant; several thousand dollars damage by falling smokestack and other property.
Wells, Marshall, Whitley, Jay, Kosciuski, Dearborn, Rush, and St. Joseph Counties, Ind.	13	do			200,000	Electrical, wind and hail.	House destroyed; large barn burned; other buildings damaged; livestock killed; heavy loss to trees and corn crop. $6,500 damage in Marshall County.
Libertyville, Ill.	13					Electrical	Barn burned.
Torrington, Wyo., and vicinity.	13					Hail	Loss amounting to 75 percent in some fields.
Daytona Beach, Fla., vicinity of.	14	3:25 p. m.		0	45	Tornado	Trees uprooted; hangar damaged at Daytona Beach airport; path 3 miles long.
Sackets Harbor, Camp Mills, and Pulaski, N. Y., and vicinities.	14	P. m.			1,500	Thunderstorm	Many trees blown down blocking highways; some damage to telephone and power lines. $500 damage to store by fallen tree. Silo blown down and barn roof damaged. $1,000 loss to barn fired by lightning.
Dothan, Ala.	14				15,000	Windstorm	Roofs, trees, power lines, and other property damaged.
Brinkley, Ark.	14				1,000	do	Barn blown down and other farm buildings damaged.
Marion, Connersville, Rochester, and Fairmont, Ind., and vicinities.	14					Rain, wind, and electrical.	Nickel Plate passenger train derailed at Marion by dirt and gravel washed across tracks, traffic delayed 5 hours. Chimney of church blown down at Connersville. Large dairy barn near Rochester and another near Fairmont burned, with several thousand dollars loss.
New Freedom, Delta, and Stewartstown, Pa.	15	3-4 a. m.	[1] 1		500,000	Tornadic winds	Many barns demolished; hundreds of livestock killed; telephone and telegraphic communication disrupted. Heavy damage to farms and loss to crops.
Sandy Hook, Freehold, Shrewsbury, Little Silver, Red Bank, Rumson, and Sea Bright, N. J., and vicinities.	15	6-6:30 a. m.			100,000	Tornadic wind and rain.	Much loss to crops; cottages, hotels, and trees damaged; communication and power lines crippled.

[1] Miles instead of yards.

Table 4.—*Severe local storms, July 1938*—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Southern Lancaster, Chester, Delaware, and Philadelphia Counties, Pa.	15	A. m.			$250,000	Electrical and wind.	Trees uprooted, small farm buildings blown down; heavy loss to crops.
Ferdinand, Idaho, vicinity of	15	12:30 p. m.	[1] 3		15,000	Heavy hail and excessive rain.	Hail damage to crops ranged from light to severe; local flooding damaged fences and soil; path 5 miles long.
Anaconda, Mont., vicinity of	15				22,000	Excessive rain and flood.	Damage to buildings, fences, bridges, and highways $15,000; loss to crops and farm property $7,000. Heaviest damage to county hospital; roads flooded; traffic stopped; loss to livestock.
Henderson County, N. C., northeast and southeast portions.	15				5,000	Hail	Loss to crops; chiefly to corn.
Oklahoma City, Okla.	15					Thunderstorm	40-foot smokestack blown down; several houses and garages damaged.
Ruble, Iowa, and vicinity	16	3-4 p. m.	[1] 1			Rain and hail	Many acres of growing crops washed away. 150 farms affected.
Graham and Trego Counties, Kans.	16	6 p. m.			25,000	High winds and hail.	Many farm buildings blown down or badly damaged. Some loss to wheat.
Appomattox County, Va., western portion.	17	4 p. m.			7,500	Heavy hail	Loss chiefly to tobacco.
Williston, N. Dak., 10 miles north.	17	7 p. m.				Rain and hail	75 percent hail damage to crops over large area.
Montgomery and Bucks Counties, Pa.	17-24				1,000,000	Heavy rains	Many small bridges and dams swept away; roadways and railroad beds undermined; cellars flooded. Crop loss $250,000.
Hitchcock and Iroquois, S. Dak., vicinities of.	18	8:40-9:30 p.m.	[1] 3			Thunderstorm and hail.	Hail stripped corn.
Judith Basin and Fergus Counties, Mont.	18	9-10 p. m.	[1] 1½		20,000	Hail	Loss to wheat crops.
Hartford, Conn., vicinity of	18-24				1,030,000	Heavy rain and flood.	Flood waters caused much damage. Coastal rivers reached new high levels for gage readings. $1,000,000 damage to tobacco; ½ of staple crops ruined; $10,000 damage to bridges and $20,000 damage to roads.
Granville County, N. C., north portion.	18					Hail	Loss to tobacco crop.
McCook, Nebr.	19	3 p. m.	[1] 2		10,000	do	Property damage.
Escanaba, Mich., vicinity of	19					do	Heavy loss to grain fields; windows damaged; no details.
Valley County, Mont., north portion.	19					Heavy hail	Loss to crops from 15 percent to total loss; no details.
East Gulf, Mead, and Killarney, W. Va.	19					Heavy rain and flood.	Stonecoal Creek overflowed; homes flooded; operations suspended in 2 coal mines.
Asbury Park, N. J., and vicinity.	19-20				10,000	Heavy rain and electrical.	Streets, highways, and cellars flooded; hundreds of automobiles stalled. Several homes and other buildings damaged by lightning.
Buckhannon and Weston, W. Va., vicinities of.	20	P. m.				Heavy rain	3 sections of railroad track washed out.
Tariff and Linden, W. Va., and vicinity.	20	do			25,000	Heavy rain and flood.	Henry's Fork out of banks causing a 2-story building to collapse; several small buildings swept away.
Bordentown, N. J., vicinity of.	20					Heavy rain	Highways flooded, bridges washed out.
White Plains, N. Y.,[2] and vicinity.	20					do	Streets, cellars, theater lobbies flooded; traffic stalled; dirt roads washed out.
Seneca County, Ohio	20				75,000	Wind and hail	Loss to crops $50,000; property damage $25,000.
Arizona, southeast portion	20-21				5,500	Heavy rain	Highways and bridges damaged.
Bluefield, W. Va.	21	7 a. m.-noon			500	Heavy rain and flood.	Streets ran curbfull; damage done to torn-up thoroughfares that were being paved.
Menomonie, Wis., 10 miles southwest.	21	11:30 a. m.-1:30 p. m.	[1] 2		500	Hail	Loss to crops $500; highways and fields damaged by rain; path 10 miles long.
Cannons Mills, Ohio, and vicinity.[2]	21	11:45 a. m.				Heavy rain	Water to depth of more than 2 feet delayed traffic; highways and bridges flooded; hundreds of motorists marooned; 2 small bridges washed away; heavy loss to gardens and cornfields.
Brewster, Nobles, and Jackson Counties, Minn., and vicinities.	21	2 p. m.	[1] 2		60,000	Hail	Corn and small grain almost total loss. Livestock suffered and some poultry perished. Some property damage. Path 15 miles long.
Lyon County, Iowa	21	2-4 p. m.	[1] 2		3,000	Hail and wind	Loss to corn crop.
Andover, S. Dak., and vicinity	21	3-4:15 p. m.	[1] 4			Hail	Loss to crops; poultry killed. Some drifts of hail over 2 to 3 feet deep.
Fisher, Minn., vicinity of	21	3:30 p. m.	[1] 3		100,000	do	About 9,000 acres of grain and sugar beets practically total loss; path 10 miles long.
Indianola, Iowa, vicinity of	21	4 p. m.	[1] 1			Hail and wind	An 80-acre cornfield stripped; 100 chickens killed; windows broken. Area about 6 miles long and hailstones piled up to depth of 10 inches.
Waterloo, Allison, and North Hampton, Iowa, and vicinities.	21	P. m.	587			do	Much loss to crops. At Waterloo 0.95 inch of rain fell in 30 minutes, flooding streets and intersections.
Lac La Croix, Minn.	21	do				Thundersquall	Camps demolished; large trees blown down and uprooted.
Carbondale and Jermyn, Pa., and vicinities.	21-23				2,000	Heavy rain and wind.	Cellars flooded and trees uprooted.
Lake Winnebago, Wis.	22	12:30 p. m.		0		Tornado	Funnel-cloud observed. No damage reported.
Phoenix, Ariz., vicinity of	22	5 p. m.	880		18,700	Wind	Roofs of buildings wrecked and carried as far as 500 feet; row of telephone poles blown down.
Chicago, Ill.[2]	22	do		3		Electrical and hail.	2 persons injured; 2 persons killed in automobile accident, another by lightning, all attributed to storm.
Eldridge and Le Claire, Iowa	22	5:30 p. m.	[1] 2-4		50,000	Hail	Loss to corn, fruit trees, and gardens.
Union Springs, N. Y.	22	P. m.				Thunderstorm and heavy rain.	Lowlands flooded; crops washed out; barn fired by lightning.
Charleston, W. Va.	22	do			30,000	Heavy rain and flood.	Streets under 2 feet of water; business houses and homes flooded.
Wellton and Roll, Ariz.	22				10,000	High wind	Loss to alfalfa seed crop.
Harrison, Ill.	22				21,000	Hail	Property damage $1,000; crop loss $20,000.
Kirkland, Ill.	22				25,000	do	Loss to crops.
Morrison, Ill., and vicinity	22				20,000	do	Loss to crops in Morrison, Ill., $10,000; in other sections of Whiteside County, $10,000.
Wichita, Kans.	22					Wind, rain, and hail.	Residence destroyed by wind. Hail in business section of city.
Clyde, N. Y., and vicinity	22					Heavy hail	Considerable loss to crops.
Rochester, N. Y., and vicinity	22				10,000	Electrical and rain.	Highways, streets, and cellars flooded; crops washed out; considerable property damage.
Sullivan and Ulster Counties, N. Y.	22					Heavy rain and flood.	Streams overflowed and washed out 3 bridges; traffic delayed by landslides; farms inundated.
Erie County, Ohio	22				100,000	Hail	Loss chiefly to truck crops.
Roane and Cabell, Counties, W. Va.	22					Heavy rain and flood.	Many small spans on secondary roads washed out.
Park County, Wyo.	22					Hail	Considerable damage; no details.
Arizona,[2] eastern portion	23	A. m.			100,000	Tornado	Several warehouses and mills demolished. Communication lines damaged, cutting off eastern portion of Arizona from outside communication.
Oswego, N. Y., vicinity of	23	3:40-4:15 p. m.	[1] 1½			Heavy hail	Several thousand dollars loss to truck crops.
Westchester County, N. Y., south portion.	23					Heavy rain	Flood water caused much damage to crops and highways; cellars flooded.

[1] Miles instead of yards.

[2] From press reports.

TABLE 4.—*Severe local storms, July 1938*—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Charleston, W. Va.[2]	23					Heavy rain	Unestimated property damage. Basements flooded and gas lines broken by more than 2 inches of rain.
Ireland, W. Va., vicinity of	23					do	U. S. Highway No. 19 blocked by landslide.
Raleigh County, W. Va	23					Heavy rain and flood.	Stonewall, Besoco, and Tommy Creeks overflowed and 1,000 persons were driven from their homes; Rhodell flooded to a depth of 3 feet; 2 highway bridges damaged and several small foot bridges washed out; landslides blocked railroad between East Gulf and Besoco.
Roane County, W. Va	23					do	3 bridges on State highway weakened.
Hartland, Minn., vicinity of	24	6 p. m.		0	$75,000	Tornado and hail	Farm buildings wrecked; machinery damaged; trees uprooted; wires down; poultry killed; 2 persons injured; loss to crops $35,000. Path 10 miles long.
Walnut Grove, Ariz., vicinity of.	24					Hail	Crops and fruit over 3-mile portion of valley a complete loss.
Parker, Ariz	24				2,500	Wind	Property damage.
Lolo, Mont	25	5 p. m.	[1]2		750	Hail	Loss to crops; a few windows broken.
Cavour, S. Dak., vicinity of	25	11:30 p. m.				Electrical	Barn, hay, and farm implements burned; 5 horses killed.
Aledo, Ill	25				15,000	Wind and hail	Property damage, $10,000; loss to crops from hail, $5,000.
Annawan, Ill	25				2,100	do	Property damage, $100; crop loss, $2,000.
Dover, Ill	25					Electrical	Barn burned.
Milan, Ill	25				1,200	Hail	Property damage, $200; crop loss, $1,000.
Monticello, Ill	25				10,000	do	Loss to crops.
Princeton, Ill	25				90,000	Rain and hail	Property, telephone and electric lines damaged $40,000; loss to crops $50,000. 2.50 inches of rain fell in 1½ hours.
Sioux Rapids, Iowa	25					Electrical	Grain elevator burned.
Valentine, Mont	26	5:45 a. m.	[1]1		1,000	Hail	Loss to crops; path 10 miles long.
Rapid City, S. Dak	26	12:27 – 12:32 p. m.			1,100	Rain and hail	Windows broken, signs blown down; hail damage to school building $1,100.
Delmar and Goose Lake, Iowa, vicinity of.	26	2 p. m.				Tornadic winds, rain, and hail.	Trees uprooted, large barn demolished and other property damage. Lines were down and roads impassable. Crops riddled by hailstones.
St. Libory to Giltner, Nebr	26	5 p. m.	[1]4		25,000	Hail and high wind	Property damage.
Hampshire, Ill	26				10,000	Hail	Loss to crops.
Princeton, Ill	26				35,000	Wind	Property damage, $15,000; crop loss, $20,000.
Wyanet, Ill	26				6,000	do	Damage to buildings, power and telephone lines.
Clinton, Iowa, vicinity of	26			0	400	Tornado	Damage to buildings and loss to crops.
Williamsburg, Petersburg, and Richmond, Va., and vicinities.	26				360,000	Heavy rains	Damage to highways.
Princeton, Ill	27				5,000	Electrical	Barn and crib burned.
Grand Rapids, Mich	28	A. m.				Thunderstorm	Streets and sewers damaged; barn burned.
Norfolk, Va	28	2:30-3 p. m.			500	do	Traffic delayed; property damage.
Concord, N. H., and vicinity	28					Thunderstorm and heavy rain.	6.63 inches of rain fell in Bow. Roads damaged; loss to crops.
Hannibal, N. Y., and vicinity	28		[1]1			Heavy hail and wind.	Several thousand dollars damage to buildings and loss to crops.
Albany, N. Y., and vicinity	29	12:35 p. m.				Tornadic wind and electrical.	Trains between Albany and Troy delayed 5 hours by washout. Numerous buildings struck by lightning; several barns burned; trees destroyed. Crops suffered. The north wall of one of the city aeroplane hangars collapsed and a section of doors carried away.
Murdo and Draper, S. Dak., vicinities of.	29	4:30 p. m.	[1]2			High wind, heavy rain and hail.	Loss to grain; wrecked shingle roofs, screened porches, windows; poultry killed.
Rock Rapids, Iowa	29	11 p. m.			10,000	Electrical	Large barn and livestock burned.
Cleveland, Ohio	29	P. m.				Thundersquall	Trees, power lines, and roofs damaged.
Stafford, Kans., vicinity of	30	4 p. m.	[1]17		9,000	High winds and hail.	Wind damage to buildings $1,000; hail damage $8,000, chiefly to crops. Path 25 miles long.
Iuka and Preston, Kans., and vicinity.	30	5 p. m.	[1]4		25,000	Heavy hail	Loss to crops; path 10 miles long.
Floral, New Salem, and Winfield, Kans., and vicinities.	30	P. m.	[1]1			High winds and hail.	Much damage to buildings from wind and to crops from hail.
Shamrock, Tex., vicinity of	31	7 p. m.	[1]1½		40,000	Hail	Loss to crops; path 25 miles long.
Tampa, Fla	31					Electrical and wind.	Departure of freighter delayed several hours; aeroplane blown over after landing.

[1] Miles instead of yards.

[2] From press reports.

U. S. GOVERNMENT PRINTING OFFICE: 1938

Chart I. Departure (°F.) of the Mean Temperature from the Normal, July 1938

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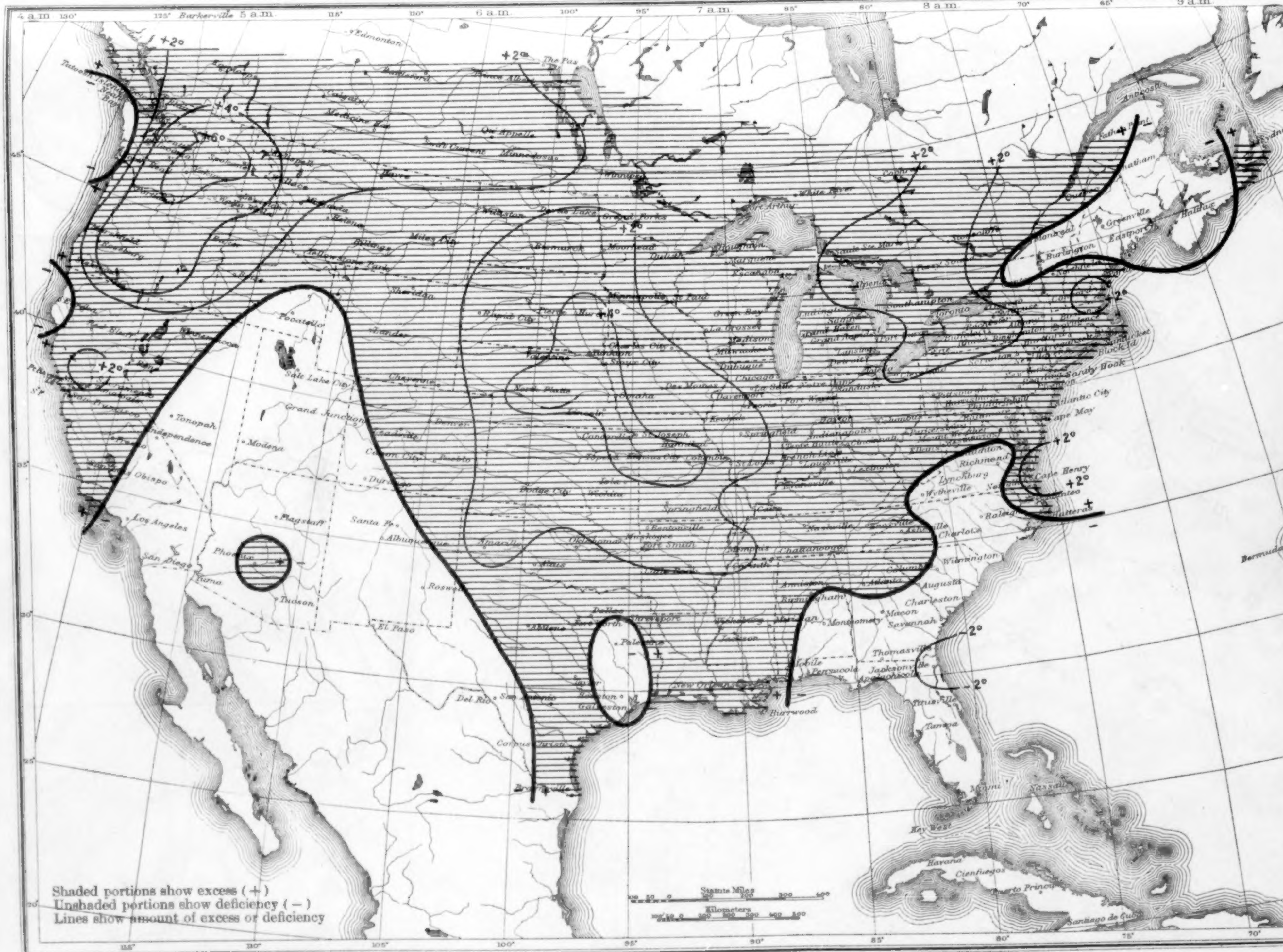
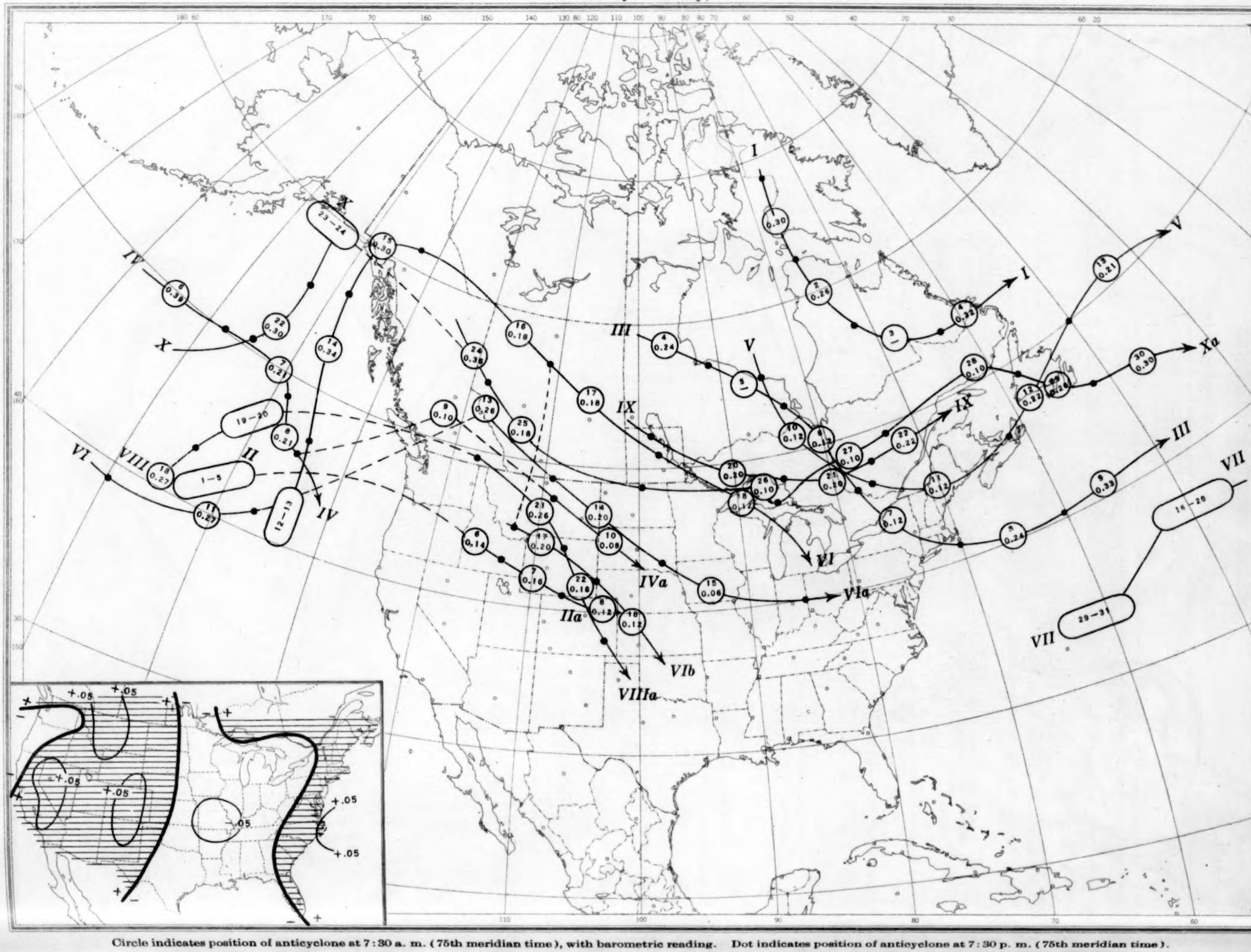


Chart II. Tracks of Centers of Anticyclones, July 1938. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by W. P. Day)



Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, July 1938. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by W. P. Day)

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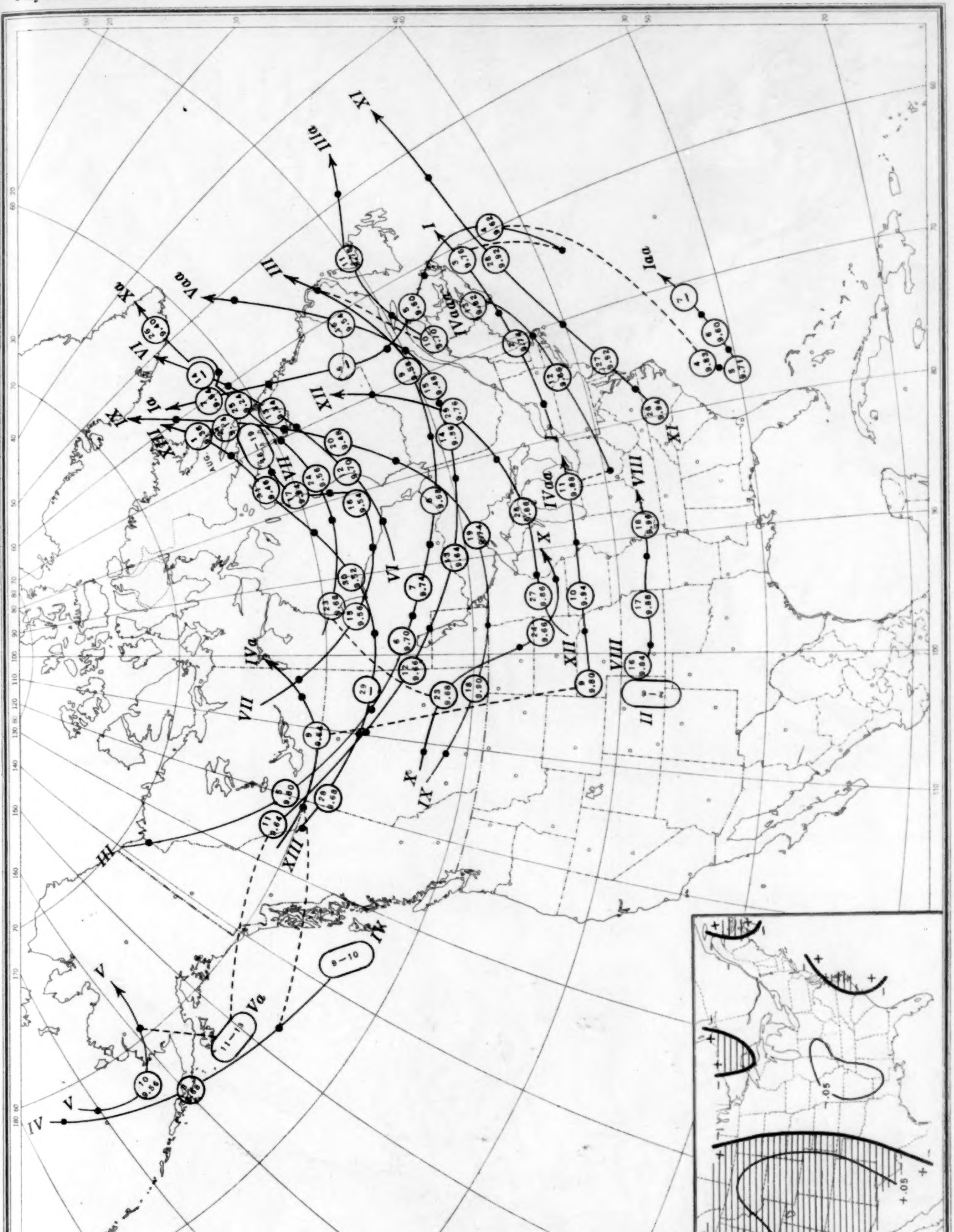
(Plotted by W. P. Day)



Circle indicates position of cyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 7:30 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, July 1938

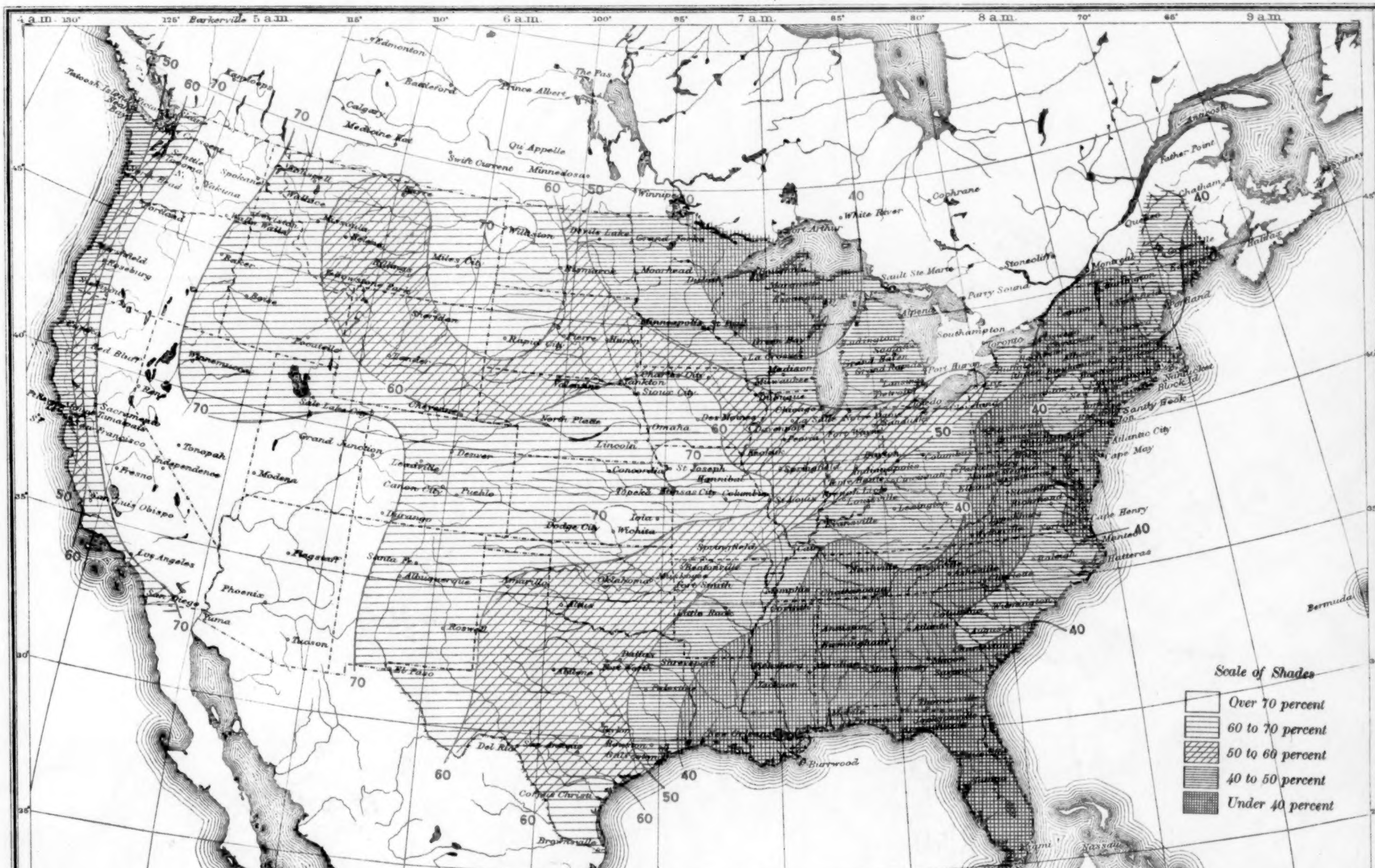


Chart V. Total Precipitation, Inches, July 1938. (Inset) Departure of Precipitation from Normal

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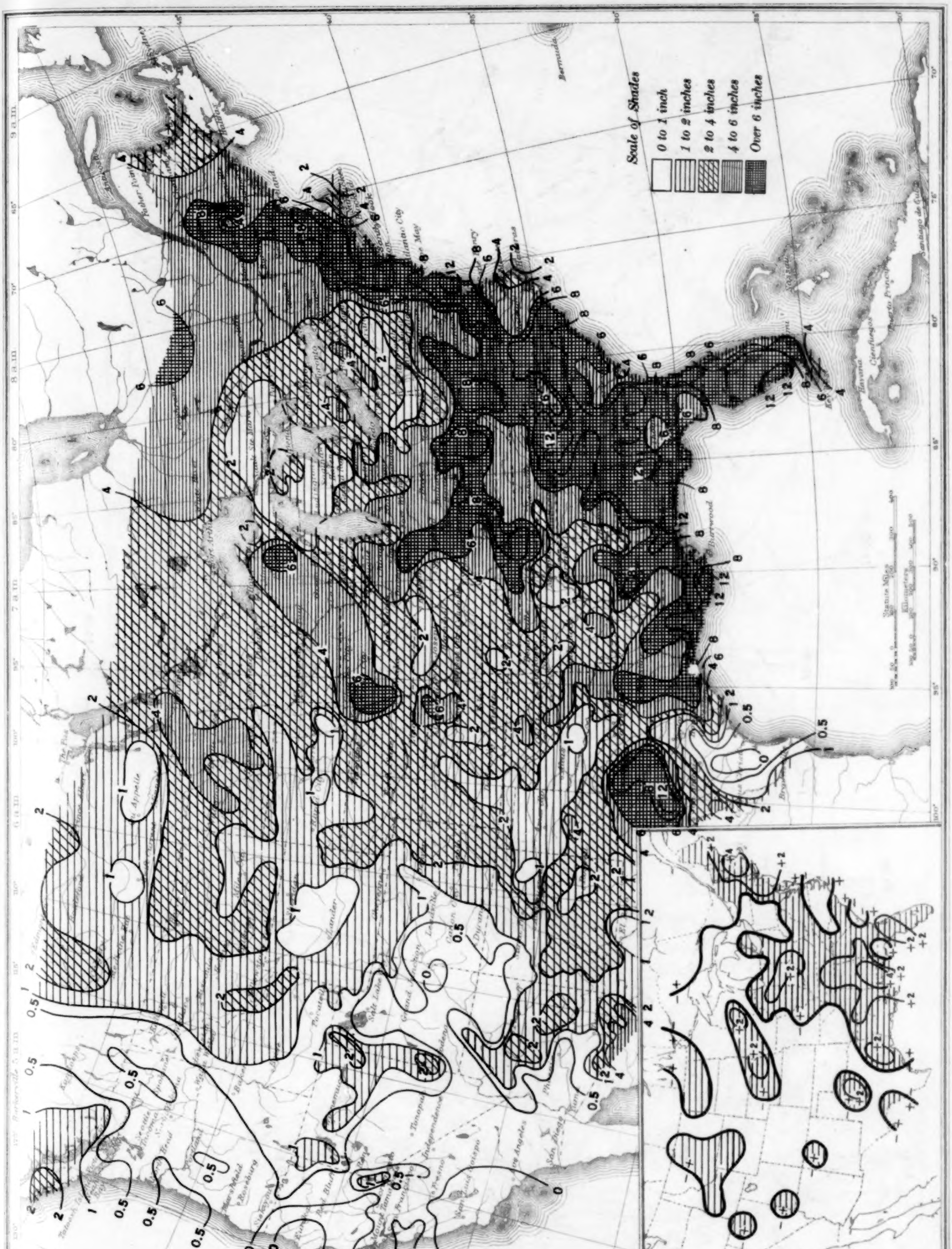

Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, July 1938

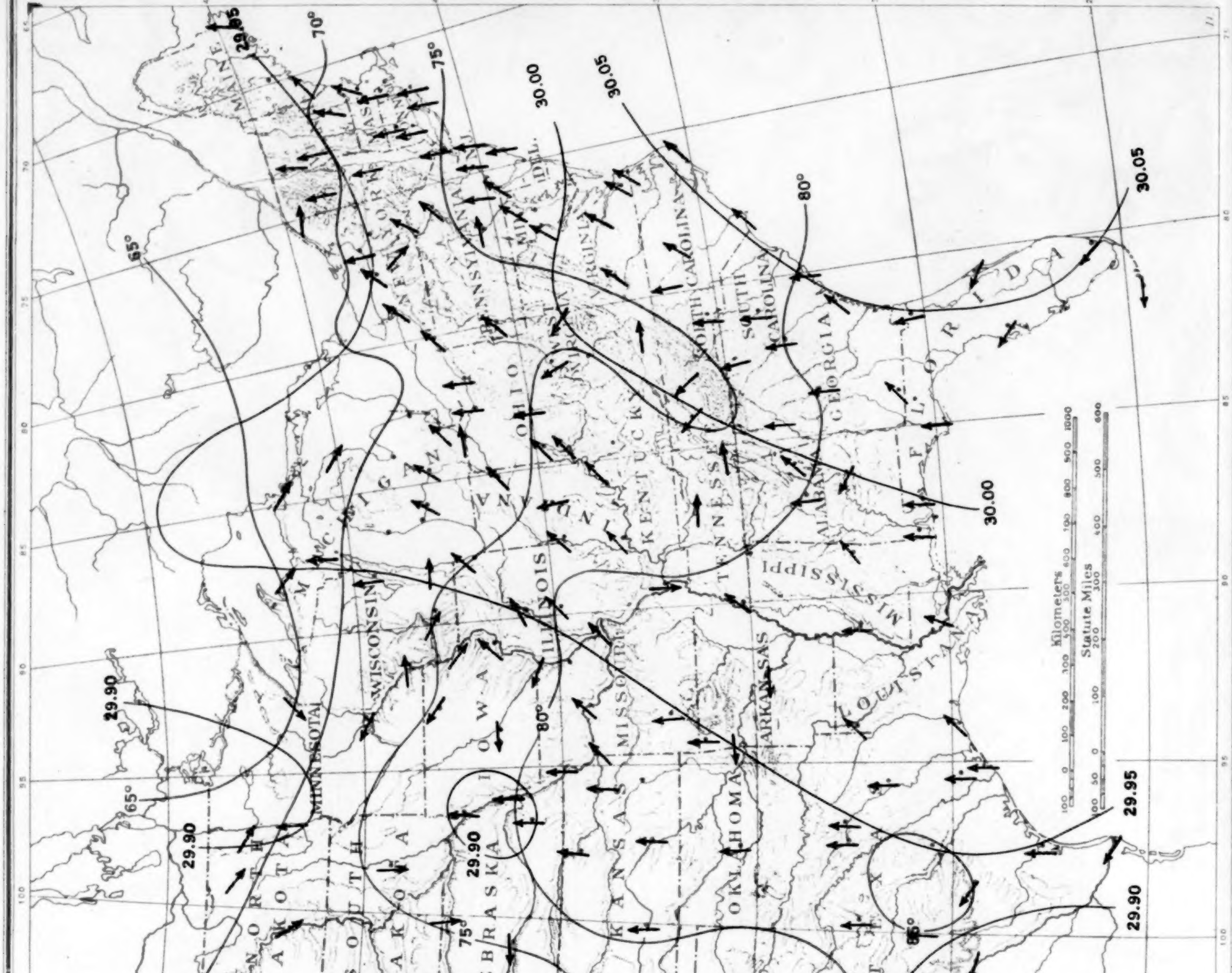

Chart VII. Wind Roses for Selected Stations, July 1938
(Plotted by W. W. Reed)

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(Plotted by W. W. Reed)